TOOELE ARMY DEPOT

Tooele, Utah

DRAFT FINAL

RISK ASSUMPTIONS DOCUMENT

Contract Number: GS-10F-0179J
Delivery Order: W91238-04-F-0045

US Army Corps of Engineers®

Submitted to:
Tooele Army Depot and
U.S. Army Corps of Engineers
Sacramento District

July 2004

PARSONS

Prepared by:
PARSONS
Salt Lake City, Utah

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AF	Adherence Factor
ASG	Active Soil-Gas
ASTM	American Society for Testing and Materials
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
BW	Body Weight
CDQMP	Chemical Data Quality Management Plan
CERCLA	Comprehensive Environmental Responsibility, Compensation, and Liability Act
cm	Centimeter
cm^2	Square Centimeter
cm^3	Cubic Centimeter
CMF	Consolidated Maintenance Facility
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CSFo	Oral Cancer Slope Factor
CSM	Conceptual Site Model
CT	Central Tendency
DRMO	Defense Reutilization and Marketing Office
DSHW	Division of Solid and Hazardous Waste
ED	Exposure Duration
EF	Exposure Frequency
EFH	Exposure Factors Handbook
EPC	Exposure-Point Concentration
f_{oc}	Fraction of Organic Carbon
ft	Feet
ft^2	Square Feet
g/g	Grams per Gram
GMA	Groundwater Management Area
gpm	Gallons Per Minute
HI	Hazard Index
HQ	Hazard Quotient
HRA	Human Health Risk Assessment
IR	Ingestion Rate
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
IWL	Industrial Wastewater Lagoon
Kg	Kilogram
Kg/L	Kilograms per Liter
L	Liter

L/Kg	Liters per Kilogram
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
µg/g	Micrograms per gram
µg/L	Micrograms per Liter
mg/L	Milligrams per Liter
mg/Kg	Milligrams per Kilogram
MW	Monitoring Well
NA	Not Applicable
NCEA	National Center for Environmental Assessment
ND	Non Detect
NEB	Northeast Boundary
NEPA	National Environmental Policy Act
NFA	No Further Action
OSWER	Office of Solid Waste and Emergency Response
PPRTV	Provisional Peer-Reviewed Toxicity Values
PSG	Passive Soil-Gas
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RfC	Reference Concentration
RfD	Reference Dose
RFI	RCRA Facility Investigation
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RME	Reasonable Maximum Exposure
SA	Surface Area
SOP	Standard Operating Procedure
SWMU	Solid Waste Management Unit
SQL	Sample Quantitation Limit
SSL	Soil-Screening Level
TCE	Trichloroethylene
TEAD	Tooele Army Depot
UAC	Utah Administrative Code
UCL	Upper Confidence Limit
UDEQ	Utah Department of Environmental Quality
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VF	Volatilization Factor
VOC	Volatile Organic Compound
VSG	Vertical Soil-Gas

SECTION 1.0
INTRODUCTION

The U.S. Army is conducting investigations of past waste disposal practices at Tooele Army Depot (TEAD) in Tooele Valley, Utah. A Phase II Resource Conservation and Recovery Act (RCRA) Facilities Investigation (RFI) for Solid Waste Management Unit (SWMU)-58 (referred to as the "site") is being conducted in accordance with TEAD's RCRA "Post Closure Monitoring and Corrective Action Permit for Solid Waste Management Units" (U.S. Army, 2001) to identify the nature and extent of known contamination, releases, and evaluate human health risks associated with soil and groundwater at SWMU-58. For clarity, SWMU-58, as defined by the Post Closure Permit, includes the Northeast Boundary (NEB) groundwater trichloroethylene (TCE) plume and vadose zone sources located within the Base Realignment and Closure (BRAC) parcel that are believed to be contributing to groundwater contamination.

1.1 BACKGROUND

A consent decree was issued in 1986 to TEAD by the United States District Court for the District of Utah, after groundwater contamination resulting from disposal of industrial wastes was discovered. The terms required TEAD to conduct an assessment of the groundwater quality; close an industrial wastewater lagoon (IWL) and associated wastewater ditches, develop groundwater cleanup levels, and prepare a Corrective Action Plan addressing groundwater remediation. The terms of the Corrective Action Plan were originally specified in the "Post Closure Permit for the Industrial Waste Lagoon" (The Permit) signed by the Division of Solid and Hazardous Waste (DSHW) and TEAD on January 7, 1991. The Permit was reissued in February 2001 as the "Post Closure Monitoring and Corrective Action Permit for Solid Waste Management Units" and is currently the governing document for restoration actions on the installation.

In addition to requiring a clean up of the groundwater, Module VII of The Permit requires corrective action investigations at a number of SWMUs. When a new SWMU is identified during the course of on-going corrective action efforts, Module VII states that,

"The Permittee [TEAD] shall notify the [State of Utah] Executive Secretary in writing of any newly identified SWMUs." As a result of the National Environmental Policy Act (NEPA) and the Environmental Baseline Survey associated with the BRAC process, eight SWMUs were added in 1994 and two in 1996. SWMU-58 was added in 1998.

1.2 RCRA CORRECTIVE ACTION PROCESS

The authority for the RCRA corrective action is derived from RCRA Section 3004(u) and is composed of four phases:

- RCRA Facility Assessment (RFA) - to identify releases and potential releases of hazardous wastes or constituents from the site;
- RCRA Facility Investigations (RFI) - to verify release(s) from the site and to characterize the nature and extent of contaminant migration;
- Corrective Measures Study (CMS) - to determine appropriate corrective measures for the site; and
- Corrective Measures Implementation (CMI) - to design, construct, operate, maintain, and monitor the proposed corrective measures.

From 1979 to the present, a series of environmental investigations have been conducted on the BRAC parcel at TEAD (refer to Parsons, 2004). These investigations, which have been conducted by both government agencies and private contractors, have ranged from general surveys to remedial investigations. SWMU-58 was identified in 1998 and a Phase I RFI for SWMU-58 was completed in 2002 (Kleinfelder, 2002). A Phase II investigation, consisting of the characterization of hazardous waste releases at the site, and an evaluation of the risk associated with these releases (where applicable), is the next step in the process. A flow chart illustrating the RFI process and the objectives of the Phase II RFI is provided as Figure 1.1. As shown in Figure 1.1, an assessment of potential human risks/hazards from exposure to site-related contaminants is one of the objectives of a Phase II RFI. The specific objectives of the human health risk assessment (HRA) are discussed in Section 1.3.

As described in the post closure permit (U.S. Army, 2001), data from the RFI will be used to support the CMS (if potential risks and/or hazards are determined to be unacceptable). The CMS will describe the alternatives for treatment or other remediation of potentially unacceptable human health risks that resulted from releases that may have occurred at SWMU-58. The options will take into account the most expedient, flexible

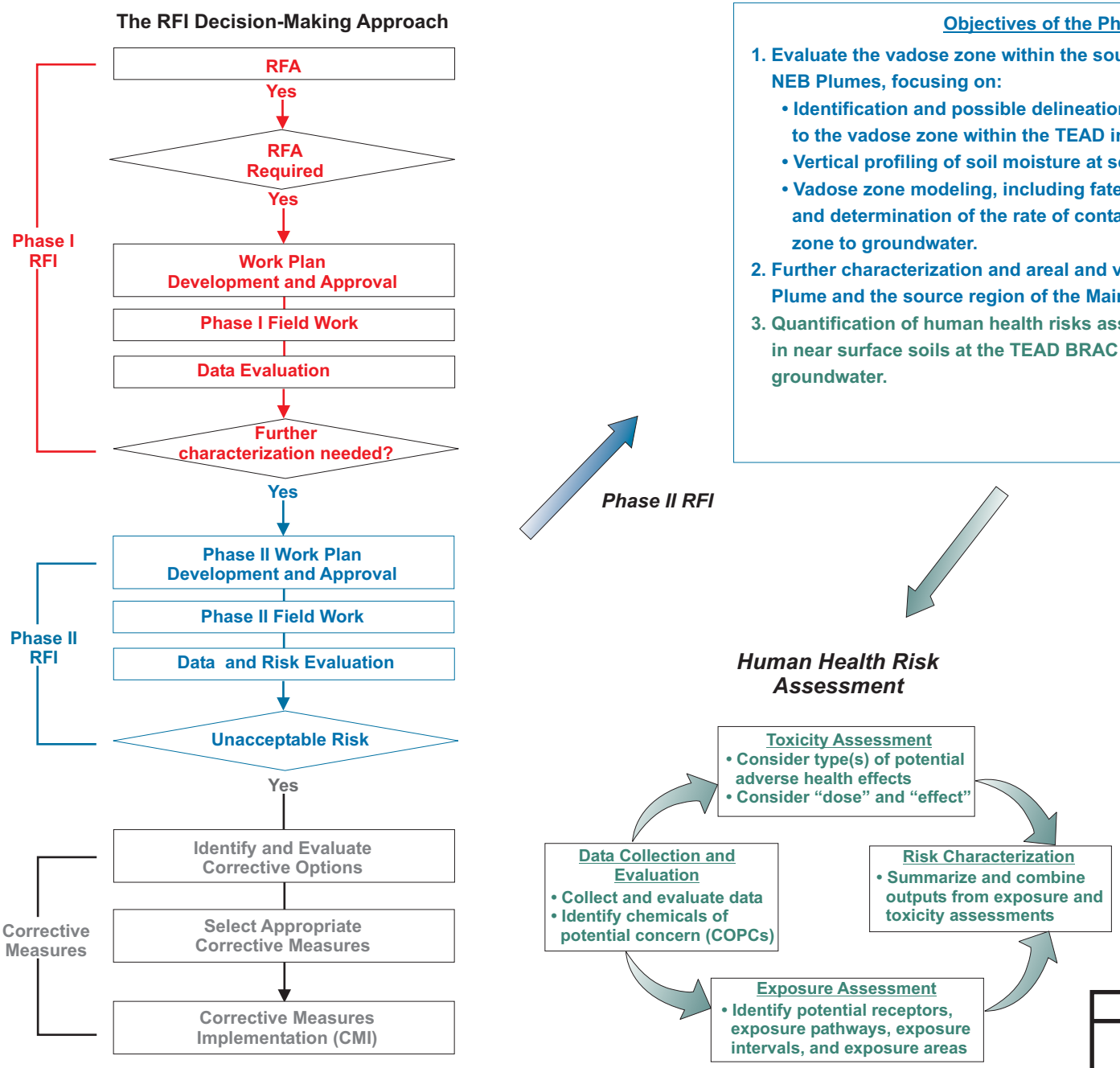

FIGURE 1.1
RISK ASSESSMENT AND THE
RFI DECISION-MAKING PROCESS

Tooele Army Depot-Tooele Valley, Utah

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remedies in order to prevent environmental degradation. The CMS also will involve the development of cleanup levels based on the information collected during the RFI.

After corrective action options have been examined in the CMS, the appropriate corrective measure will be selected for implementation and will be submitted to the Executive Secretary of the Utah Department of Environmental Quality (UDEQ) for approval in the CMI Program Plan, along with a compliance schedule. Following approval, the corrective measure will be implemented. This stage of work will involve the design, construction, operation, maintenance, and monitoring of the proposed corrective measure.

1.3 OBJECTIVES

As described in U.S. Army (1999a) and United States Environmental Protection Agency (USEPA, 1989a), the overall objectives of a human health risk assessment are to: 1) collect and evaluate site data, including the development of a conceptual site model (CSM) and the identification of chemicals of potential concern (COPCs); 2) estimate potential exposure to the relevant human receptors; 3) assess the potential toxicity of site-related COPCs; and 4) characterize the risks and/or hazards associated with potential exposure to site-related COPCs. A COPC is defined as a chemical detected at a hazardous waste site that has the potential to affect receptors adversely due to its concentration, distribution, and mode of toxicity. Specific Phase II RFI risk assessment objectives at SWMU-58 will be to: 1) quantify the risks and/or hazards associated with exposure to volatile organic compounds (VOCs) at the BRAC parcel via indoor air and shallow surface soil pathways; and 2) assess human health risks associated with potential non-potable use of impacted groundwater within portions of the NEB plume. The purpose of this risk assessment assumptions document is to describe specific methods and exposure assumptions that will be used to characterize potential human risks and/or hazards associated with exposure to contaminants at SWMU-58.

An ecological risk assessment will not be conducted at SWMU-58 because there are no complete and/or significant exposure pathways. This is supported by the fact that: 1) the site lacks suitable foraging habitat for wildlife species as it is located within a developed area primarily used for commercial/industrial purposes; 2) the vegetation that

is present within the BRAC parcel is not a valued resource (i.e., it is insufficient to sustain viable ecological populations); and 3) ecological receptors potentially present in the NEB plume area are not exposed to site-related COPCs in groundwater given a depth-to-groundwater of ≥100 feet (ft) below ground surface (bgs). SWMU-58 encompasses in excess of 50 buildings within a rectangular-shaped parcel approximately one mile long by one-half mile wide. The majority of the surface around the buildings is paved and used for roads. The natural environments in areas that are unpaved are regraded or covered with fill material with minimal vegetation.

This risk assumptions document will be submitted to DSHW for concurrence prior to conducting the HRA to ensure risk- and rule-based decision criteria used in the risk assessment conducted for Phase II reflect a consensus among TEAD and state regulators, and are both protective and practical.

1.4 REGULATORY GUIDELINES

The HRA will be conducted in accordance with Utah Administrative Code (UAC) R315-101 (DSHW, 2001). UAC R315-101, *Cleanup Action and Risk-Based Closure Standards,* establishes information requirements to support risk-based cleanup and closure standards at sites for which remediation or removal of hazardous contaminants to background levels will not be achieved.

Current U.S. Army, USEPA, and/or other commonly accepted methods will be used to assess risks and/or hazards associated with potential exposure to site-related contaminants at SWMU-58. The HRA methods will be based on, but not limited to, the following sources:

- Risk Assessment Handbook, Volume I: Human Health Evaluation (U.S. Army Corps of Engineers [USACE], 1999a);
- Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989a);
- Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" (USEPA, 1991a);
- Volume I - Human Health Evaluation Manual (Part B, development of Risk-based Preliminary Remediation Goals) (USEPA, 1991b);

- Dermal Exposure Assessment: Principles and Applications, Interim Report, Office of Research and Development (USEPA, 1992a)
- Guidance on Risk Characterization for Risk Managers and Risk Assessors (USEPA, 1992b);
- Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA, 1992c);
- Guidance for Data Usability in Risk Assessment (Part A). Final (USEPA, 1992d);
- Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure, Preliminary Review Draft (USEPA, 1993a);
- Supplemental Guidance to RAGS: Estimating Risk from Groundwater Contamination (USEPA, 1993b);
- Soil Screening Guidance: Technical Background Document (USEPA, 1996);
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Peer Review Draft (USEPA, 2001a);
- Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Peer Review Draft (USEPA, 2001b);
- Land Use in the Comprehensive Environmental Responsibility, Compensation, and Liability Act (CERCLA) Remedy Selection Process (USEPA, 1995);
- Exposure Factors Handbook (USEPA, 1997a);
- User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion Into Buildings (Revised) (USEPA, 2000a);
- User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings (USEPA, 2003a);
- Human Health Toxicity Values in Superfund Risk Assessments. Memorandum (USEPA 2003b); and
- Draft Guidance for Evaluating the Vapor Intrusion Indoor Air Pathway from Groundwater and Soils (USEPA, 2002a).

1.5 ORGANIZATION

This assumptions document consists of six sections and an appendix, including this introduction. The outline of this document is consistent with the four-step HRA evaluation process described in U.S. Army (1999a) and USEPA (1989a) and is as follows:

SECTION 2.0

DATA COLLECTION/EVALUATION AND IDENTIFICATION OF COPCS

Per USACE (1999a) and USEPA (1989a), the data collection/evaluation step involves collecting and reviewing all relevant site data and identifying COPCs (i.e., chemicals with a potential to pose unacceptable risks/hazards to the identified receptors). The steps involved in data collection have been discussed in the Final Work Plans (Parsons, 2003a and 2004). As shown in Figure 2.1, the primary data evaluation steps include; 1) a review of site characterization information; 2) a refinement of the preliminary CSM; 3) an evaluation of analytical data for usability in risk assessment; and 4) the identification of COPCs.

2.1 REVIEW OF SITE-CHARACTERIZATION INFORMATION

As described in Parsons (2003a), the site-characterization objectives of the Phase II RFI are to: 1) evaluate the vadose zone within the source areas for the Main and NEB Plumes; and 2) characterize horizontal and vertical groundwater impacts to the NEB plume and the source region of the Main plume. A brief summary of the historical data used to identify the initial suspected source areas in the vadose zone and impacts to the Main and NEB groundwater plumes is provided in the following subsections (refer to Parsons, 2003a for more details). However and as discussed in the SWMU-58 Phase II Work Plan (Parsons, 2003a), additional soil-gas, shallow soil, and groundwater data are being collected to further characterize: 1) the lateral and vertical extent of contamination; 2) potential source areas in the vadose zone that may be a continuing source of groundwater contamination; and 3) subsurface fate and transport properties that will be used in refined vadose zone and/or groundwater modeling. Phase I and/or II soil-gas, shallow soil, and groundwater data will be used to evaluate human health risks (refer to Section 2.3, Data Usability).

2.1.1 Vadose Zone

The Phase I RFI (Kleinfelder, 2002) consisted of passive soil-gas (PSG) and active soil-gas (ASG) sampling over approximately 800 acres within the BRAC parcel, with the intent of locating VOC source areas contributing to the underlying groundwater contamination. During the PSG survey, approximately 1000 GORE-Sorber® Screening Modules were installed throughout the parcel to identify the presence or absence of VOCs in the subsurface. Approximately 20 ASG sampling points were then installed within the former industrial area at locations exhibiting the highest PSG detections; soil-gas samples were collected from 6 to 10 ft bgs. Based on these results and other historical information, five vertical soil-gas (VSG) monitoring wells were installed, each with 10 soil-gas sampling ports evenly-spaced from the ground surface to approximately 20 ft above the water table. At four of the five locations where VSG monitoring wells were installed, chlorinated hydrocarbons were detected throughout the vadose zone to within 20 ft of the groundwater table. This observation provided strong evidence of continuing VOC migration to the groundwater in these areas.

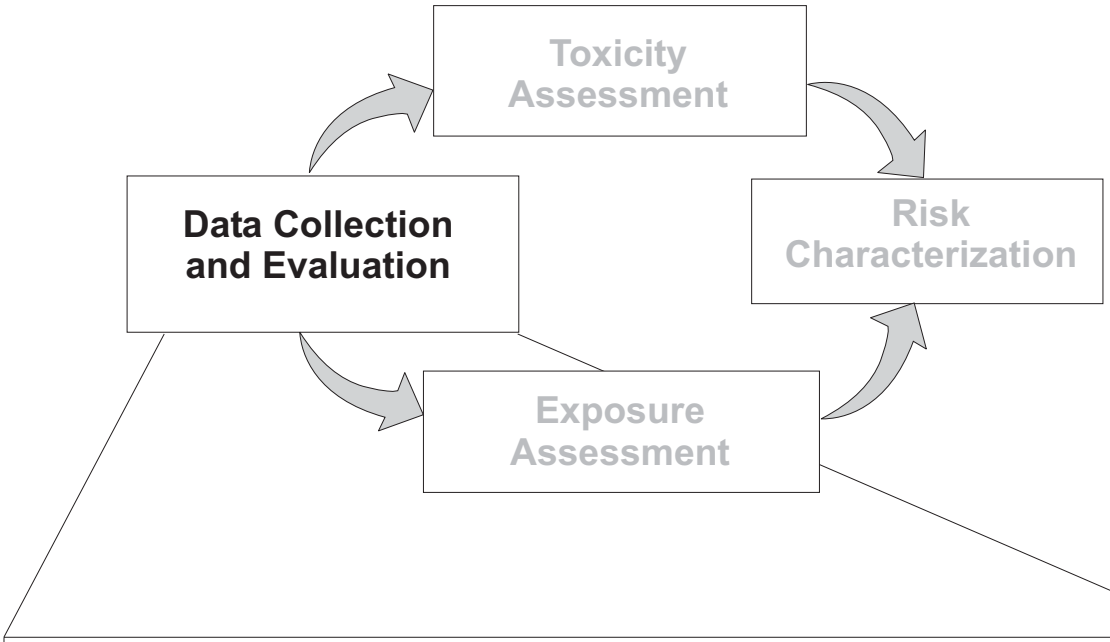
As a result of the passive, active, and vertical soil-gas data collected, three regions were identified as likely source areas contributing to the groundwater contamination plumes:

- Building 679 oil/water separator.
- Former outfall ditches along Avenues A, B and C and the west side of Building 600.
- The assemblage of buildings between Avenues B and E at the south end of the industrial area where virtually all of the vehicle and equipment maintenance, repair, and renovation activities occurred.

A number of sites within these areas were identified for further investigation for the Phase II RFI. Results from the soil-gas investigation were used extensively for locating exact sites for additional soil-gas sampling. Refer to the SWMU-58 Work Plan (Parsons, 2003a) for PSG, ASG, and VSG sampling points and a summary of the results from the initial Phase I investigation.

2.1.2 Main Plume

In 1983, the U.S. Army began to investigate groundwater contamination related to wastewater discharges to a former IWL and associated unlined wastewater ditches. The



- **Review site characterization information (e.g., nature and extent of contamination, soil types, and depth-to-groundwater)**
- **Refine preliminary conceptual site model based on results of data evaluation**
  - **sources, release mechanisms, and affected media**
  - **current/future land use**
  - **potential receptors and exposure pathways**
- **Evaluation of analytical data for usability in risk assessment**
  - **combine data collected during Phase I and II field efforts**
  - **evaluate analytical methods, quantitation limits, qualifiers, and blanks**
- **Identify chemicals of potential concern (COPCs)**

FIGURE 2.1

DATA COLLECTION AND EVALUATION

Tooele Army Depot-Tooele Valley, Utah

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U.S. Army concluded that these discharges produced a plume of VOCs, primarily TCE, located beneath and downgradient of the IWL and wastewater ditches. This plume was designated the Main Plume by previous investigators. The IWL and the associated ditches were capped in 1989, under the aforementioned Corrective Action Permit issued by the State of Utah. These features were considered to be the most significant sources of the VOC plume; however, other locations in the Industrial Area at TEAD may have also contributed to the release (Kleinfelder, 1998a).

Remediation of groundwater associated with the Main Plume began in 1993. Currently, it processes up to 7500 gallons per minute (gpm) of groundwater from 16 extraction wells through air stripping towers, then reinjecting the treated water through downgradient injection wells located near the northern boundary of the plume.

Groundwater monitoring is conducted semiannually to assess contamination. Since 1993, TCE and carbon tetrachloride concentrations have been increasing in some wells in the industrial area, indicating that residual TCE is present in soil.

2.1.3 Northeast Boundary Plume

In 1986, TCE was detected in an offsite production well located north of the Industrial Area, approximately 5000 ft northeast of the IWL. In 1994, the U.S. Army installed Wells C-10 and C-11 at the northeastern boundary of TEAD. TCE was detected at a concentration of approximately 240 micrograms per liter (µg/L) in groundwater sampled from Well C-10, located directly across the road from the impacted offsite production well (Kleinfelder, 1998b).

Additional groundwater investigations were conducted to further assess the nature and extent of groundwater contamination at the northeastern boundary of TEAD. These additional investigations indicated that the contamination in Well C-10 and the adjacent offsite production well had likely originated from a source different from that attributed to the Main TCE plume. Thus, two plumes of groundwater contamination were indicated. The original plume has been designated the Main Plume. The second, more easterly plume, was designated the NEB Plume. The oil-water separator at Building 679 in the former industrial area was identified as a major source of the NEB plume (Kleinfelder, 2000). A subsequent investigation defined the approximate offsite extent of the NEB Plume (Parsons, 2002). The plume, which is relatively narrow beneath the former

industrial area, extends approximately 16,000 ft downgradient (to the north) from the identified source at Building 679.

2.2 CONCEPTUAL SITE MODEL

As described in USACE (1999a) and USEPA (1989a), CSMs are effective tools for defining site dynamics, streamlining risk assessments, establishing exposure hypotheses, and developing appropriate corrective actions. CSMs are useful for identifying completed exposure pathways between physical media affected by site-related contamination and potential receptors. The purpose of a CSM is to aid in understanding and describing a site and to present assumptions regarding:

- Suspected sources and types of contaminants present;
- Contaminant release and transport mechanisms;
- Affected media;
- Potential receptors that could contact site-related contaminants in affected media under current or future land use scenarios; and
- Potential routes of exposure.

The first step in developing a CSM is to characterize a site with respect to operational, environmental, and chemical characteristics, and the current and anticipated future land uses at and near the site. Understanding site conditions and land uses aids in the identification of potential receptors under current and future exposure scenarios. The final step in developing CSMs is to identify which potential receptor exposure pathways are (or may be) completed and which are (and are likely to remain) incomplete. An exposure pathway is not considered to be complete unless all four of the following elements are present:

- A source and mechanism for chemical release;
- An environmental transport/exposure medium;
- A receptor exposure point; and
- A receptor and a likely route of exposure at the exposure point.

Only completed exposure pathways for which adequate data are available will be evaluated quantitatively in the risk assessment. Potential sources, release mechanisms, affected media, land use scenarios, potential receptors, and potential exposure pathways

at SWMU-58 are summarized in the general CSM (Figure 2.2) and discussed in the following subsections. Site-specific CSMs for each exposure area at SWMU-58 will be developed, however, a general discussion of sources, release mechanisms, and affected media, land use scenarios, environmental transport/exposure media, potential receptors, and potential exposure pathways is provided in the following subsections.

2.2.1 Sources, Release Mechanisms, Affected Media

Known and suspected releases of chlorinated solvents to the vadose zone within and peripheral to the former TEAD industrial area fall into six broad categories with respect to origin, process, and location: 1) leaks along branch and trunk lines that comprise the old storm/industrial waste water piping system; 2) infiltration of industrial wastewater that was conveyed along the unlined wastewater ditches west of the industrial area; 3) release(s) due to waste disposal at the Sanitary Landfill; 4) leaks along drain lines beneath and directly adjacent to buildings where solvents were used; 5) redistribution of contamination along runoff pathways and within retention areas via major precipitation events; and 6) accidental spills and incidental releases.

These releases can also be characterized by: 1) the type of containment structure (if applicable); 2) release mechanism; 3) geometry of the release; 4) chlorinated solvent phase(s); and 5) estimated frequency, duration, rate, and volume of the release type (Parsons, 2003a). Attributes of the six release types listed above are summarized in the SWMU-58 Work Plan and are not repeated here.

The predominant type of chlorinated solvent release in the former TEAD industrial area is suspected to be dilute (i.e., aqueous) concentrations related to breaches of the industrial wastewater conveyance system. No records or information were encountered that document, discuss, or suggest the release of pure chlorinated solvent to the vadose zone within the former TEAD industrial area. Previous work has not encountered any direct evidence for residual solvent phase, either in the vadose zone or in groundwater. Residual solvent phase contamination, if present, likely resulted largely from the handling and storage of solvent products. Pure or slightly dilute solvent may have also been released at the landfill and/or as a result of leaks present along drain lines underlying and immediately adjacent to buildings housing solvent-use processes. It is presumed that any pure solvent releases were volumetrically small and perhaps confined

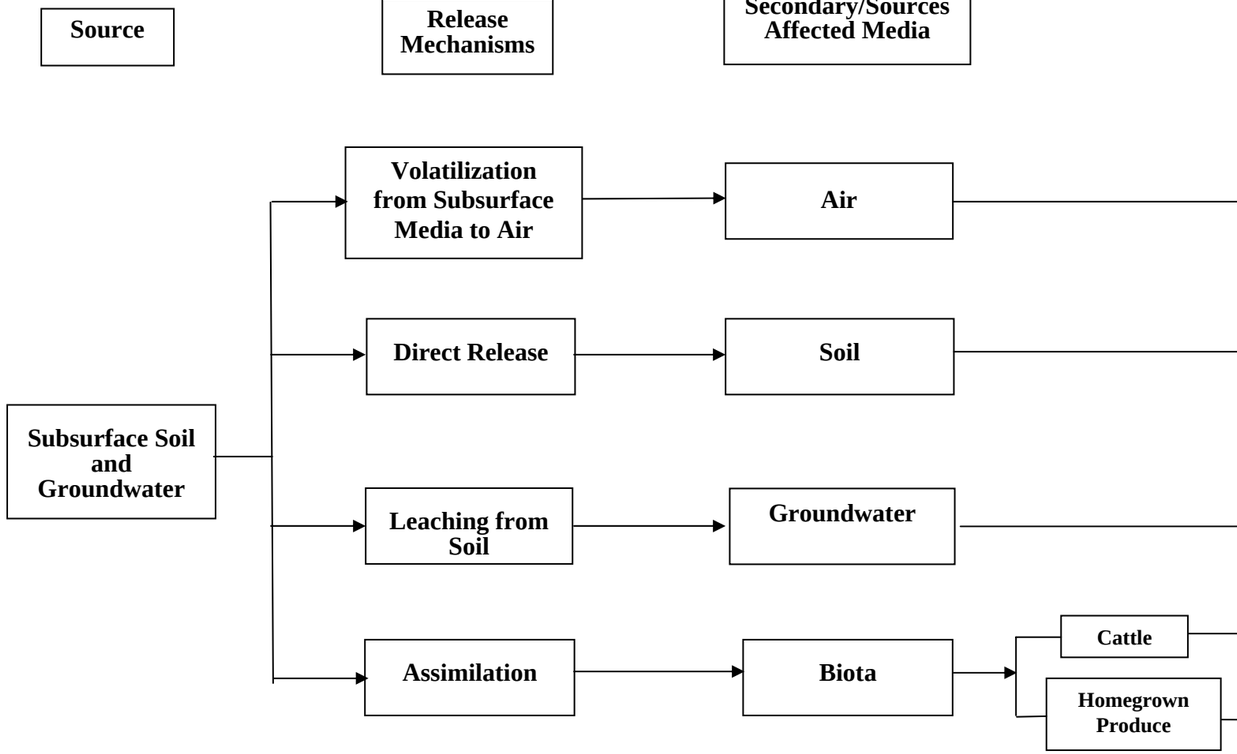
to a very limited number of locations. Most surface and shallow subsurface solvent releases within the former industrial area have been characterized as a point source, with a very small areal footprint. The Phase II investigations are designed to confirm and refine the above conclusions and/or assumptions.

2.2.2 Current/Future Land Use

TEAD is located 35 miles southwest of Salt Lake City, Utah in eastern Tooele County. The facility covers approximately 25,000 acres of the Tooele Valley. TEAD's previous mission began in 1942 and included servicing, rebuilding, and storage of wheeled vehicles and power generation equipment used by the U.S. Army. Industrial activities were carried out in the industrial area (former vehicle maintenance area), which is situated along the eastern margin of the facility and just south of highway SR112 (Figure 2.3). The industrial area encompasses in excess of 50 buildings within a rectangular-shaped parcel approximately one mile long by one-half mile wide, exclusive of the Defense Reutilization and Marketing Office (DRMO) area, and the Consolidated Maintenance Facility (CMF). Activities conducted in support of these missions required the use of various solvents and other materials (Kleinfelder, 2002). TEAD's current mission includes storage, maintenance, and demilitarization of conventional weapons and ammunition.

A portion of TEAD, including most of the industrial area (Figure 2.3), was formally transferred to the City of Tooele in December 1998 as part of the BRAC Program. The City of Tooele subsequently sold its interest in the property to the current private concerns. The former TEAD industrial area was and continues to be developed for commercial/industrial, warehousing, and distribution operations. Therefore, current and reasonably expected future land use for evaluating potential exposures to site-related chemicals in soils and groundwater at TEAD's property and the BRAC parcel within the SWMU-58 boundary (Figure 2.3) will be assumed to be industrial and/or commercial. The private property north of highway SR112 and within the SWMU-58 investigative area (Figure 2.3) is primarily used for agricultural purposes (e.g., crop production and cattle grazing).

Although there are no known current domestic users of the potentially impacted groundwater beneath the private property north of highway SR112 within the SWMU-58



Exposure Route	Current and/or Future Human Receptors		
	Indoor Worker	Intrusive Worker	Resident
Inhalation of VOCs Volatilized from Subsurface Soil-Gas	X	O	O
Inhalation of VOCs Volatilized from Groundwater	O	O	O
Inhalation [a/]	O	X	O
Ingestion	O	X	O
Contact	O	X	O
Inhalation [b/]	O	O	O
Ingestion	O	O	X
Contact	O	O	O
Ingestion of Contaminated Milk/Beef	O	O	O
Ingestion	O	O	O

Legend:

X = Pathway potentially complete and evaluated quantitatively.

O = Pathway evaluated qualitatively and determined to be incomplete or potentially complete, but insignificant.

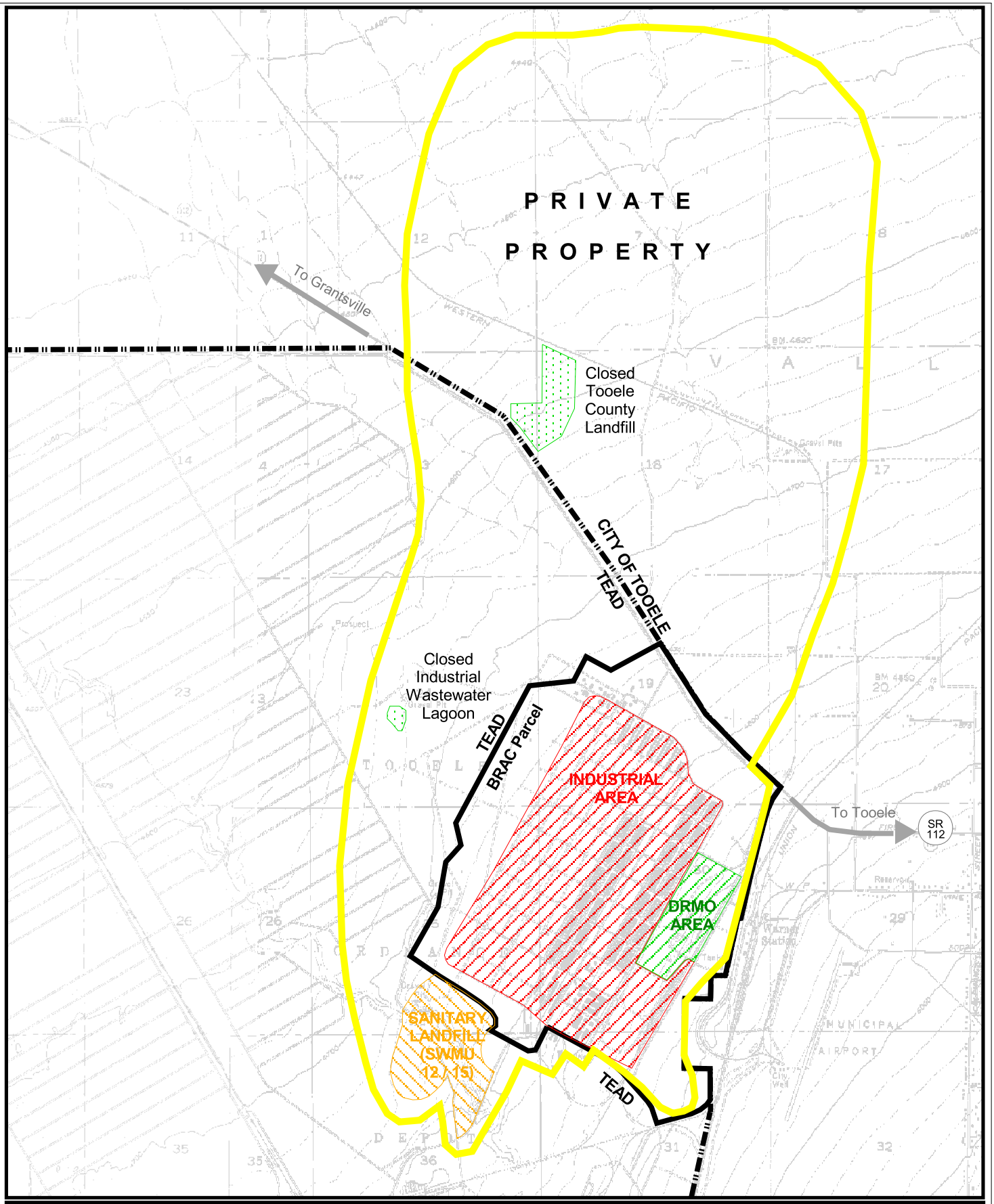
[a/] Inhalation of VOCs from the shallow subsurface soil interval (~2-7 ft bgs).

[b/] Inhalation of VOCs volatilized from groundwater during domestic use.

FIGURE 2.2

CONCEPTUAL SITE MODEL FOR RECEPTOR EXPOSURE PATHWAYS AT SWMU-58

TOOELE ARMY DEPOT - TOOELE VALLEY, UTAH


PRIVATE
PROPERTY
To Grantsville
Closed
Tooele
County
Landfill
CITY OF TOOELE
TEAD
Closed
Industrial
Wastewater
Lagoon
TEAD
BRAC Parcel
INDUSTRIAL
AREA
DRMO
AREA
To Tooele
SR
112
SANITARY
LANDFILL
(SWMU
12 / 15)
TEAD
LEGEND
Approximate Boundary
of Project Area
BRAC Parcel
Industrial Area
DRMO Area
SWMU 12 / 15
TEAD Boundary
FIGURE 2.3
PROJECT AREA
LOCATION MAP
2000
0
2000 Feet
N
SWMU 58 - PHASE II RFI - TOOELE ARMY DEPOT - TOOELE, UTAH
w:/tooele/maps/risk_assumptions/project_location.apr Plot Date: 5/11/04
2-9
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boundary (Parsons, 2004), it will be assumed that this groundwater will be used for domestic purposes in the future in order to facilitate risk management and groundwater monitoring decisions. Domestic use of groundwater is defined as groundwater uses related to activities of households and private residences (e.g., ingestion). Domestic use of groundwater does not include the application of water to plants sold or consumed (by humans or livestock), or for watering livestock.

One privately owned well is located north of highway SR112 within the SWMU-58 boundary and is used in gravel operations (industrial use). No other known current non-potable users of the potentially impacted groundwater beneath the private property north of highway SR112 within the SWMU-58 boundary were identified (Parsons, 2004). However, non-potable use of potentially impacted groundwater beneath the private property north of highway SR112 within SWMU-58 will be considered. Non-potable uses include application of potentially impacted groundwater to plants sold or consumed (by humans or livestock), watering livestock, or using potentially impacted groundwater for industrial processes.

2.2.3 Potential Receptors

Potential receptors are defined as humans that may contact (i.e., be exposed to) site-related contaminants in environmental media (and possible ingestion of meat/dairy products and produce impacted by COPCs in groundwater). Consistent with USEPA (1989a, 1995) guidance, current and reasonably anticipated future land use were considered when selecting potential receptors. The following potential human receptors at SWMU-58 will be quantitatively evaluated in the risk assessment:

- Current and/or future indoor workers (potentially exposed to soil-gas COPCs)
- Future intrusive workers, such as construction workers or workers that install/repair utility lines (potentially exposed to soil COPCs)
- Future residents with domestic wells in impacted groundwater north of highway SR112 (potentially exposed to groundwater COPCs)

Commercial and/or industrial workers potentially exposed to COPCs in groundwater beneath TEAD and the BRAC property via the drinking water exposure route will not be evaluated quantitatively. The U.S. Army currently controls commercial and/or industrial exposures to COPCs in groundwater within TEAD and the BRAC

property by restricting access. TEAD concedes that unrestricted exposure to groundwater with concentrations above drinking water standards (i.e., maximum contaminant levels [MCLs]) poses an unacceptable risk, and intends to control use of all groundwater with concentrations above the MCL. A table showing groundwater concentrations beneath TEAD and the BRAC property compared with drinking water standards will be presented in the risk assessment.

Indoor industrial workers potentially exposed to COPCs volatized from groundwater used for industrial processes (e.g., gravel washing) will not be evaluated quantitatively since potential volatilization of COPCs from groundwater used in industrial process cannot be predicted with a satisfactory degree of confidence at this time. Appropriate models and associated input assumptions, such as the industrial processes currently or reasonably expected to be used, the flux of volatile emissions during use of the groundwater, the area of the emissions source, the location of the potential receptor relative to the breathing zone of the emission source, etc. are highly uncertain and/or not available. In addition, and as discussed in USEPA's (2002a), *Draft Vapor Intrusion Guidance*, the Occupational Safety & Health Administration (OSHA) is also responsible for addressing occupational exposures for inhalation of chemicals volatilized into industrial buildings.

2.2.4 Exposure Pathways

As defined by USEPA (1989a), an exposure pathway is, "The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air) or media (in cases of intermedia transfer) also is included." A review of potential exposure pathways links the sources, locations, and types of environmental releases with receptor locations and activity patterns to determine the significant pathways of concern.

The following exposure pathways will be evaluated quantitatively in the risk assessment (Figure 2.2):

- Incidental ingestion of soil during intrusive activities (future intrusive workers)

- Dermal contact with soil during intrusive activities (future intrusive workers)
- Inhalation of VOCs from soil during intrusive activities (future intrusive workers)
- Inhalation of VOCs volatilized from subsurface soil-gas into indoor air (current and/or future indoor workers)
- Ingestion of groundwater (future residents with domestic wells in impacted groundwater north of highway SR112)

Soil exposure pathways, including incidental ingestion, dermal contact (intrusive workers), and inhalation of VOCs volatilized from subsurface soils into indoor air (indoor workers) will be evaluated for potential exposures at TEAD's property and the BRAC parcel within the SWMU-58 boundary. The following exposure pathways will not be assessed quantitatively for the reasons specified:

- **Ingestion of groundwater by commercial and/or industrial workers within TEAD and the BRAC property.** The potential receptors and pathway will not be evaluated quantitatively for the reasons discussed in Section 2.2.3.
- **Ingestion of meat and/or dairy products from cattle ingesting groundwater from wells in the NEB plume north of highway SR112 (future consumers of locally produced meat and/or dairy products).** Impacted groundwater may be used in the future as stock water for beef and/or dairy cattle, which could result in VOC uptake into beef and/or dairy products. A health protective screening level of 21,000 µg/L of TCE in groundwater was calculated for this pathway as part of the interim corrective measure discussed in the Groundwater Management Area report (Parsons, 2004). Concentrations of TCE in the NEB plume north of highway SR112 have been orders of magnitude below this screening level; the maximum detected concentration of TCE was 220 µg/L in 2003 (Parsons, In Preparation). Other VOCs were detected in wells sampled north of highway SR112; however, they were: 1) isolated low-level detections and/or not detected in repeated sampling events; and 2) significantly lower than corresponding TCE detections (Parsons, 2003b). In addition, these VOCs are significantly less toxic than TCE. Therefore, potential cumulative risks and/or hazards from ingestion of meat and/or dairy products from cattle ingesting groundwater from the NEB plume north of highway SR112 are insignificant relative to the potential hypothetical residential drinking water ingestion exposure pathway, and will not be calculated and incorporated quantitatively into the cumulative HRA risk calculations.
- **Dermal contact and inhalation of COPCs during indoor domestic use of potentially impacted groundwater north of highway SR112 (future residents with private wells).** Although these pathways have not been selected for quantitative evaluation, the risks and/or hazards are not generally greater than the

ingestion pathway since exposures (and subsequent risks) from dermal contact and inhalation of COPCs during indoor domestic use are approximately equivalent to or less than the ingestion exposure route (USEPA, 1991c).

- **Inhalation of COPCs volatilized from potentially impacted groundwater into outdoor or indoor air (current and/or future commercial and/or industrial workers and future residents north of highway SR112).** The depth-to-groundwater near the NEB plume is approximately 100 ft bgs. Per USEPA (2002a), volatilization of chemicals into outdoor or indoor air is thought to be insignificant if the contamination is located at least 100 ft away (horizontally and/or vertically).
- **Outdoor inhalation of COPCs volatilized from impacted groundwater used as stock water (future farmers north of highway SR112).** Outdoor volatilization and subsequent inhalation by farmers of COPCs from surface stock water obtained from potentially impacted groundwater is an incomplete/insignificant exposure route because: 1) volatilized chemicals are quickly dispersed in ambient air; and 2) farmers are not exposed to the primary breathing zone (i.e., the zone directly above the surface stock water).
- **Ingestion of fruits and vegetables irrigated with groundwater from impacted wells (future residents north of highway SR112 using private wells to water home gardens).** Significant uptake of volatiles (e.g., TCE) into fruits and vegetables via this pathway is not likely because the COPCs are expected to volatilize from the irrigation water and soil surface before significant plant uptake can occur. This assumption is consistent with the Hill Air Force Base (HAFB) 1992 Final Baseline Risk Assessment for Operable Unit 2.
- **Ingestion of meat and/or dairy products from cattle exposed to COPCs volatilized from groundwater into outdoor air (consumers of locally produced meat and/or dairy products).** Volatilization of COPCs from groundwater north of highway SR112 into outdoor air is insignificant based on the depth-to-groundwater, as described above.
- **Inhalation of COPCs volatilized from potentially impacted groundwater used for industrial processes (indoor and/or outdoor industrial workers).** Risks and/or hazards based on potential volatilization and subsequent inhalation of COPCs from groundwater used in industrial processes will not be derived for the reasons described in Section 2.2.3.

2.2.5 Exposure Areas

According to USEPA (1996) guidance, an exposure area is defined as a geographical area within which a receptor can be expected to move randomly and may be exposed to contamination over time. Potential exposure areas will be dependent upon the affected media, the exposure routes, and the receptors of interest. The area within the

NEB plume north of highway SR112 is defined as the exposure area for future residents that may drink impacted groundwater. Initially, the exposure area for the soil and soil-gas-to-indoor air exposure pathways will be assumed equivalent to the entire SWMU-58 investigative area (Figure 2.3) since maximum detected concentrations in soil and soil-gas will be used to estimate risks and/or hazards. If target risks and/or hazards are exceeded, the exposure areas for the soil and soil-gas-to-indoor air pathways will be refined based on a review of the Phase II site characterization data (e.g., areas near existing buildings may be defined as unique exposure areas for the subsurface soil-gas-to-indoor air pathway).

2.3 ANALYSIS OF DATA FOR USABILITY

Phase I (active soil-gas samples; Kleinfelder, 2002) and Phase II active soil-gas data (Parsons; In Preparation) will be used in the HRA (volatilization into indoor air and subsequent inhalation by indoor workers), Phase II shallow soils data (future intrusive workers), and groundwater data from the four most recent sampling events (i.e., last 2 years, collected semiannually; future residents that ingest impacted groundwater) will be used in the risk assessment. After combining the usable analytical data that meet the project data quality objectives and eliminating those analytes not detected in any samples in a particular medium, the data will be further evaluated on the basis of quality, with respect to method detection limits (MDLs) and sample quantitation limits (SQLs), laboratory qualifiers, blanks, and duplicates. All data to be used in the risk assessment will have been validated in accordance with the project Sampling and Analytical Plan (Parsons, 2003a) and the Chemical Data Quality Management Plan (CDQMP; USACE, 1999b). Specifically, data verification will have been performed on 100-percent of the data, and data validation will have been performed on 10-percent of the data. Based on *Guidance for Data Usability in Risk Assessment (Part A)* (USEPA, 1992d) and *RAGS* (USEPA, 1989a), verified/validated sample data will be used in the risk assessments as described in the following paragraphs.

Unqualified (i.e., detected and valid) analyte values will be included, and rejected ("R"-qualified) data will be excluded from the risk assessment data sets. Per USEPA (1992d), “Data qualified with an ‘R’ are rejected because performance requirements in

the sample or in associated quality control (QC) analyses were not met." An example might be a mass spectrometer that is "out-of-tune," which results in unacceptable confidence in the identification and quantitation of a chemical. Analytes not detected ("U"-qualified) in any sample of a given matrix at SWMU-58 will be excluded from the risk assessment data set for that matrix. A comparison of the detection limits with risk-based screening levels will be conducted and results will be discussed in the uncertainty section.

Values reported as estimated ("J"-qualified) will be included in the risk assessment data sets and used the same way as positive data that do not have this qualifier. Data qualified as "J" indicate uncertainty in the reported concentrations, but not in the assigned identities and are "estimated" because quantitation in the samples or in the associated quality control samples does not meet validation criteria. Potential uncertainties associated with the use of "J"-qualified data will be discussed in the risk assessment.

If a chemical is detected at least once in a specific medium at SWMU-58, surrogate values for any nondetects ("U"-qualified results) for that analyte generally will be included in the risk assessment data sets at one-half the associated SQL. In other words, "U"-qualified data generally will be usable in assessing potential exposure (USEPA, 1989a). Per USEPA (1992d), "The SQL is the MDL adjusted to reflect sample-specific action such as dilution or use of a smaller aliquot for analysis due to matrix effects or the high concentration of some analytes." SQLs are used in the data evaluation step because they take into account sample characteristics, sample preparation, and analytical adjustments, and are considered to be the most relevant quantitation limits for evaluating nondetected chemicals (USEPA, 1989a). However, if the SQL for a given nondetect sample is greater than two times the maximum detected concentration for the given analyte in a specific matrix within an exposure area, the datum will be considered anomalous and will be excluded from the risk assessment data sets. USEPA (1989a) recommends excluding nondetected results from the risk assessment data set if the SQL is "unusually high" or if they cause the estimated exposure concentration to exceed the maximum detected concentration for a particular data set.

When two or more values are available for a given sample/location/date (e.g., duplicates), the average of the values will be used. If all values for a given sampling location are nondetects, and a value is required for the risk assessment data set (i.e., other sampling locations at the SWMU have unqualified or "J"-flagged values), the value with the lowest SQL will be selected. If at least one value is unqualified or "J"-flagged and the other value(s) is a nondetect, the average will be calculated assuming one-half the SQL for the nondetect(s).

As discussed in the SWMU-58 Work Plan (Parsons, 2003a), samples from 20-percent of all Phase II soil-gas samples analyzed in the field will also be sent to a fixed (i.e., commercial) laboratory for analysis. Field versus fixed laboratory soil-gas analytical results will be compared and the data will be treated as duplicates and processed as described above if the results are comparable. Alternatively, the Phase II analytical soil-gas data (field or fixed laboratory results) that best represent actual COPC concentrations will be determined, retained for the risk assessment data set, and justification provided in the risk assessment.

2.4 IDENTIFICATION OF COPCS

All organic compounds detected at least once in a given media will be retained as COPCs for analysis in the risk assessment. The final list of COPCs for analysis in the risk assessment likely will include multiple chemicals from the following target Phase II VOC analytes (reproduced from Table 4.6 of the SWMU-58 Work Plan; Parsons, 2003a):

- Benzene
- Carbon Tetrachloride
- Chloroethane
- Chloroform
- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,1-Dichloroethene
- *cis*-1,2-Dichloroethene
- *trans*-1,2-Dichloroethene
- 1,2-Dichloropropane
- Ethylbenzene
- Methylene Chloride
- Naphthalene
- Tetrachloroethene
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- TCE
- Toluene
- m,p-Xylenes
- o-Xylene
- Vinyl Chloride

SECTION 3.0
EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the type and magnitude of potential exposures to site COPCs. The results of the exposure assessment are combined with results from the toxicity assessment to characterize potential risks. Per USEPA (1989a), exposure assessment is a three-step process involving characterization of the exposure setting, identification of exposure pathways, and quantification of exposure. In order to accomplish these three steps, it is important to; 1) finalize the conceptual site model; 2) estimate exposure-point concentrations (EPCs); 3) determine exposure assumptions; and 4) quantitatively estimate exposure (Figure 3.1). Characterization of the exposure setting and the identification of all potentially exposed receptors and exposure pathways have been discussed in Section 2. Specific justification for including or excluding a medium, a receptor(s), and/or an exposure route(s) from the CSM was also discussed in Section 2. Estimation of EPCs, methods for estimating exposure, and recommended exposure assumptions are discussed below.

3.1 EXPOSURE-POINT CONCENTRATIONS

EPCs are intended to be representative of the concentrations of chemicals in a given medium to which a receptor may be chronically exposed at a specific site (i.e., the exposure point). Maximum or estimates of average COPC concentrations will be used when calculating initial or refined exposure estimates, respectively. USEPA (1989a) recommends using an estimate of the upper confidence limit (UCL) on the arithmetic mean as an EPC for chronic exposures in those instances where it is appropriate to group data from a particular medium (e.g., soil, soil-gas, and groundwater). EPCs will be estimated using Phase I and/or II analytical data or using modeling (e.g., COPC concentrations in air due to volatilization from soil or soil-gas).

3.1.1 Soil EPCs

Soil EPCs will be calculated and used for estimating exposure via incidental ingestion, dermal contact, and inhalation by an intrusive worker only (Section 2.2). Per

USEPA (1996), the depth over which soils are sampled should reflect the type of exposure expected at the site. As discussed in Standard Operating Procedure (SOP) P02 of the SWMU-58 Work Plan (Appendix A of Parsons, 2003a), shallow subsurface soil samples will be collected between approximately two and seven ft bgs. This shallow subsurface (~2-7 ft bgs) interval will be used as the likely soil exposure interval for an intrusive worker based on the potential that short-term intrusive activities may require excavations up to 7 ft bgs. As discussed in Section 2.2.5, maximum detected concentrations from the entire SWMU-58 investigative area will conservatively be used as soil EPCs to estimate risks and/or hazards. If additional calculations are warranted, and adequate data are available, average soil concentrations will be used as soil EPCs and will be based on 95-percent UCLs. Average concentrations will be calculated by grouping data from within refined exposure areas delineated based on a review of the Phase II RFI site-characterization data (refer to Section 2.2.5).

USEPA (1989a) recommends using an estimate of the UCL on the arithmetic mean as an EPC for chronic exposures in those instances where it is appropriate to group data from a particular medium (e.g., soil and soil-gas). Methods for calculating UCLs are summarized in the flowchart shown on Figure 3.2. Statistical methods for calculating UCLs are dependent on the distribution of the data (USEPA, 1989b, 1992e, 1997b, 2000b, 2002b, and 2004a). USEPA's (2002b) Office of Solid Waste and Emergency Response (OSWER) guidance on "*Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*" states that, "Before an appropriate method can be selected the site data must be characterized through exploratory analysis. Fitting distributions to the data is a crucial part of this exploratory data analysis."

Current USEPA-recommended methods for fitting distributions and calculating 95-percent UCLs are discussed in USEPA (2002b) and the User's Guide of ProUCL Version 3.0 (hereafter referred to as ProUCL and referenced as USEPA, 2004a). USEPA has worked with its contractor, Lockheed Martin to develop the ProUCL software package to perform the distributional tests and UCL calculations described in the OSWER guidance (USEPA, 2002b). ProUCL Version 3.0 can be used to assign data distributions and calculate 95-percent UCLs when adequate data are available. However, the User's Guide for ProUCL (USEPA, 2004a) does not address minimum sample size

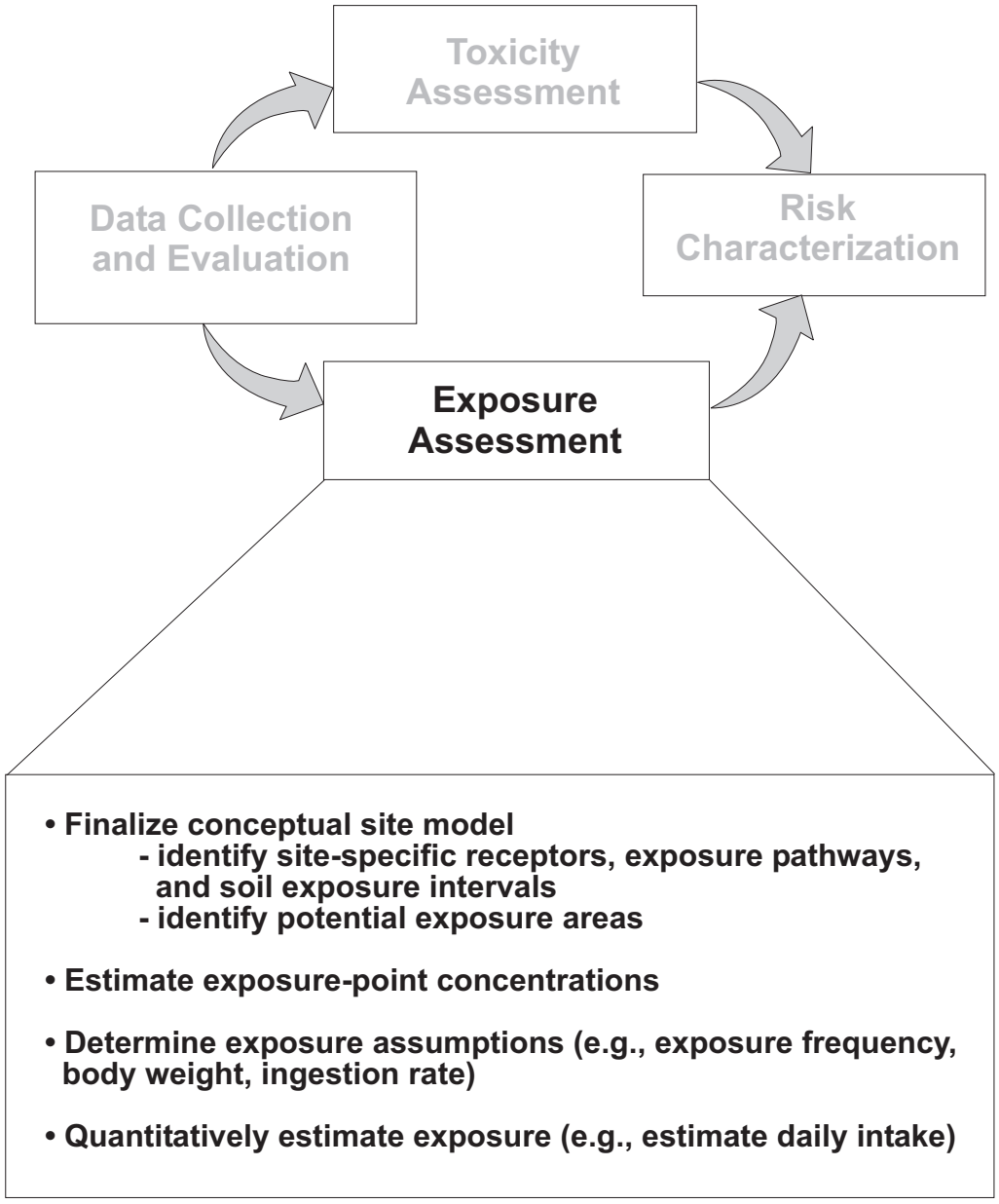

FIGURE 3.1

EXPOSURE ASSESSMENT

Tooele Army Depot-Tooele Valley, Utah

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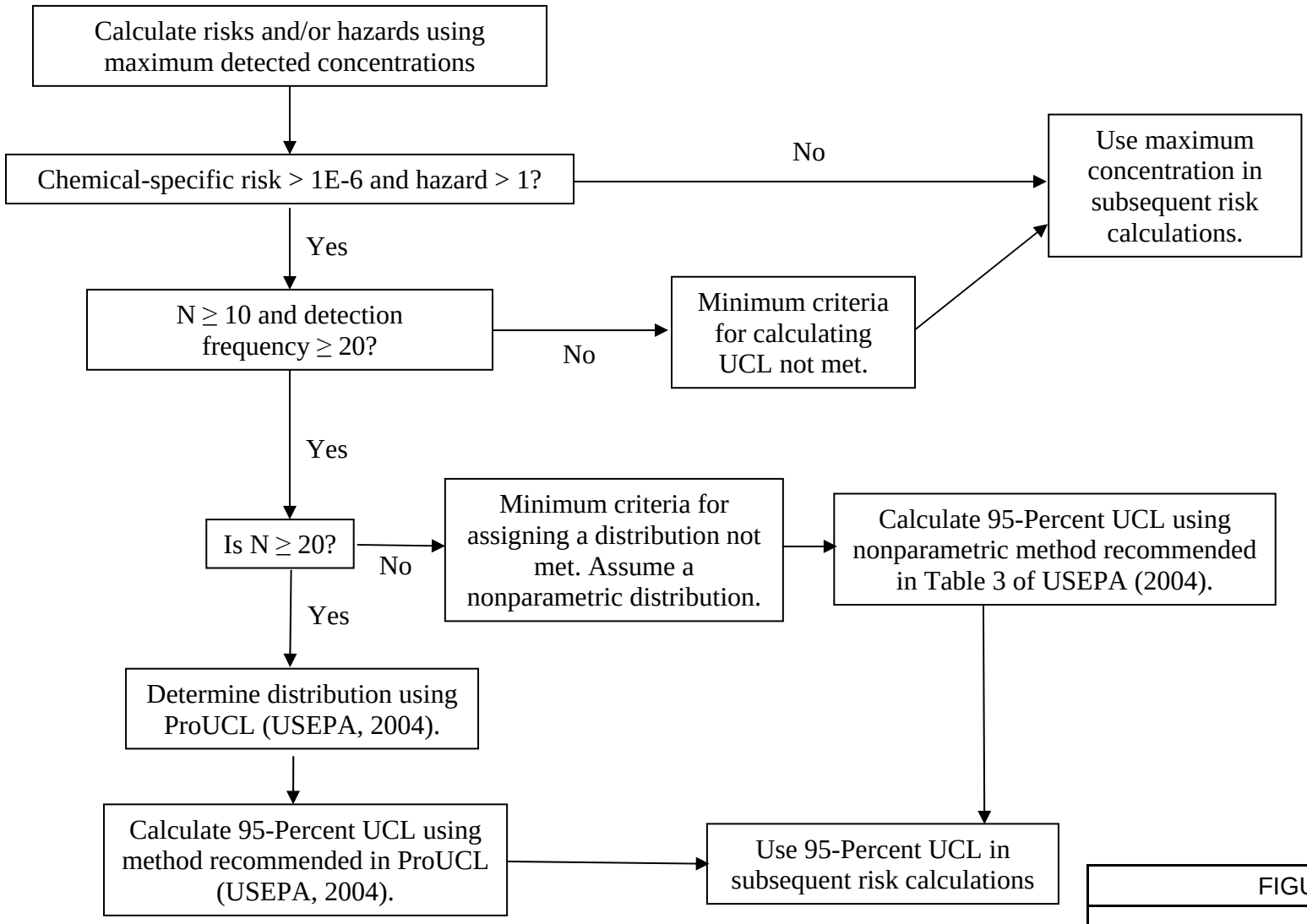


FIGURE 3.2

ASSIGNING DISTRIBUTIONS AND CALCULATING 95-PERCENT UCLS

TOOELE ARMY DEPOT - TOOELE VALLEY, UTAH

PARSONS

requirements for assigning distributions to the data and subsequently, for estimating 95-percent UCLs.

3.1.1.1 Minimum Sample Size for Conducting Distributional Tests

Distributional tests can be performed on datasets with sample sizes as small as three (USEPA, 2000b). However, the tests lack statistical power for small sample sizes and no matter which distributional test is used, it may fail to detect deviations from normality due to a lack of power (or increased likelihood of committing a “false-positive” [Type II] decision error) (USEPA, 2000b). USEPA (1989b) states that, "All tests of distributional assumptions require a fairly large sample size to detect moderate to small deviations from normality." Very little USEPA guidance exists on the minimum sample size recommended for achieving adequate “power” for the formal distributional tests incorporated into ProUCL (i.e., Shapiro-Wilk, Lilliefors, Komogorov-Smirnov, and Anderson-Darling tests). USEPA (1989b) does recommend a minimum sample size of 50 for the Komogorov-Smirnov test. Other literature sources identified to-date recommend a minimum sample size of anywhere between 10 and 50 for distributional tests. The formal distributional tests in ProUCL will only be used to assign a distribution type with datasets that contain at least 20 samples (i.e., $N \geq 20$), which is a reasonable and practical minimum number of samples to achieve an “acceptable” level of power based on a review of USEPA guidance and other literature sources conducted to-date. Datasets with fewer than 20 samples (i.e., $N < 20$) will be assumed to be nonparametrically distributed *a priori*, which is consistent with USEPA (1989b, 1992e, 1997b, and 2000b) recommendations to use nonparametric techniques (i.e., methods that are independent of the distribution type) when assumptions of normality or lognormality cannot be adequately justified.

3.1.1.2 Minimum Sample Size and Detection Frequencies for Calculating UCLs

The minimum number of samples needed to calculate UCLs is dependent on factors such as the size of the exposure area, heterogeneity of the medium, spatial pattern of contamination, receptors and/or exposure pathways, expected variance, and the acceptable false-negative (Type I) and positive (Type II) error rates. Per USEPA (1992e), “Sampling data from Superfund sites have shown that datasets with fewer than 10

samples per exposure area provide poor estimates of the mean concentrations (i.e., there is a large difference between the sample mean and the 95-percent UCL)…." UCLs will not be calculated and maximum detected concentrations will be used as EPCs for datasets with fewer than ten samples (N < 10) and/or less than 20-percent detections (refer to Figure 3.2), as these are generally considered reasonable minimum criteria for estimating statistically appropriate UCLs. As discussed in Section 2.3, nondetect results will be replaced by one-half the MDL. Although USEPA (2002b) recommends conducting a "bounding analysis" for datasets with greater than 15-percent nondetects, USEPA's more recent (2004a) guidance states, "The issue of estimating the 95-percent UCL of the mean with varying degrees of censoring (e.g., 15-50-percent, 50-75-percent, greater than 75-percent, etc.) is currently under investigation" (USEPA, 2004a). USEPA (2002b) guidance indicates that if nondetects are replaced by surrogate values (e.g., detection limits or one-half the detection limits) and used to calculate UCLs, that value is "likely to be considerably larger than the true mean." Therefore, replacing nondetect values with one-half the detection limit is considered "health protective".

3.1.1.3 Summary of Distribution Testing and UCL Methods

The purpose of this section is to briefly summarize the methods for fitting distributions and calculating 95-percent UCLs that have been incorporated into USEPA's (2004a) ProUCL (Version 3.0). Refer to the User's Guide of ProUCL for a detailed discussion of the methods. ProUCL has incorporated formal statistical tests for determining if a dataset fits a normal, lognormal, or gamma distribution. Datasets that do not fit any of these distribution types are assumed to be nonparametrically distributed. Tests for normality (or lognormality) utilized by ProUCL include the Shapiro-Wilk and Lilliefors tests for sample sizes of ≤50 and >50 (up to 1000), respectively. Tests utilized by ProUCL for gamma distributions include the Anderson-Darling and Kolmogorov-Smirnov tests. In addition to these formal tests, ProUCL includes the option to graphically generate and evaluate distributional fits using histograms and quantile-quantile (Q-Q) plots.

ProUCL recommends a computational method for calculation of the 95-percent UCL based on the assumed distribution. There are fifteen different UCL computational methods incorporated into ProUCL.

The five parametric UCL computational methods include:

1- Student's-t UCL
2- Approximate gamma UCL using chi-square approximation
3- Adjusted gamma UCL (adjusted for level significance)
4- Land's H-UCL
5- Chebyshev inequality based UCL (using minimum variance unbiased estimates [MVUEs] of parameters of a lognormal distribution)

The ten nonparametric methods included in ProUCL are:

1- The central limit theorem (CLT) based UCL
2- Modified-t statistic (adjusted for skewness) based UCL
3- Adjusted-CLT (adjusted for skewness) based UCL
4- Chebyshev inequality based UCL (using sample mean and sample standard deviation)
5- Jackknife method based UCL
6- UCL based upon standard bootstrap
7- UCL based upon percentile bootstrap
8- UCL based upon bias-corrected accelerated (BCA) bootstrap
9- UCL based upon bootstrap-t
10- UCL based upon Hall's bootstrap

Criteria for selection of the computational method, as well as the formulae for the computational methods, are provided in USEPA (2004a) and are not repeated here. UCLs will be based on a default confidence coefficient of 0.95 (i.e., 95-percent confidence) and the default of 2000 iterations will be used when calculating the UCL using bootstrapping methods. Unless specified, the 95-percent UCL recommended by ProUCL, based on the assumed distribution type, will be used as the EPC.

For nonparametric datasets where $10 \leq N < 20$, a nonparametric computational 95-percent UCL method will be selected based on sample size (N) and standard deviation ($\hat{\sigma}$) per the criteria listed in Table 3.1 (reproduced from Table 3 of ProUCL).

3.1.2 Air EPCs

Air EPCs will be used to estimate exposure to intrusive worker and indoor worker receptors from inhalation of air impacted by site-related COPCs. Because air monitoring

TABLE 3.1

UCL COMPUTATIONAL METHOD CRITERIA FOR NONPARAMETRIC DATA DISTRIBUTIONS

SWMU-58

TOOELE ARMY DEPOT - TOOELE VALLEY, UTAH

$\hat{\sigma}$	Sample Size (N)	Recommendation
$\hat{\sigma} \leq 0.5$	For all N	95% UCL based upon Student's-t statistic or Modified-t statistic
$0.5 < \hat{\sigma} \leq 1.0$	For all N	95% Chebyshev (Mean, Sd) UCL
$1.0 < \hat{\sigma} \leq 2.0$	N < 50	99% Chebyshev (Mean, Sd) UCL
	N > 50	97.5% Chebyshev (Mean, Sd) UCL
$2.0 < \hat{\sigma} \leq 3.0$	N < 10	Hall's Bootstrap UCL
	N > 10	99% Chebyshev (Mean, Sd) UCL
$3.0 < \hat{\sigma} \leq 3.5$	N > 30	Hall's Bootstrap UCL
	N < 30	99% Chebyshev (Mean, Sd) UCL
$\hat{\sigma} > 3.5$	N < 100	Hall's Bootstrap UCL
	N > 100	99% Chebyshev (Mean, Sd) UCL

data will not be available, the inhalation exposure route will be evaluated using USEPA-recommended soil-to-outdoor air (USEPA, 1996) or soil gas-to-indoor air (USEPA, 2003a) models. Methods for calculating the EPCs for the inhalation route are described in Sections 3.3.3 and 3.3.5. Maximum soil-gas concentrations initially will be used to estimate air concentrations. If additional calculations are warranted, and adequate data are available, (i.e., sufficient number [N ≥ 8] of samples and detection frequency [>20-percent]) average soil and soil-gas concentrations will be used to calculate air EPCs and will be based on 95-percent UCLs (using methods described in Section 3.1.1). Average concentrations will be calculated grouping data from within refined exposure areas delineated based on a review of the Phase II RFI site-characterization data (refer to Section 2.2.5).

3.1.3 Groundwater EPCs

Groundwater EPCs will be used for estimating exposure to future residents that may drink impacted groundwater from the NEB plume north of highway SR112. Groundwater concentrations are expected to vary (e.g., decrease) over the exposure duration (e.g., 30 years; see Section 3.2 below) used to estimate risks and/or hazards. For example, the rate at which the COPC plume moves during the next 30 years, both horizontally and vertically, is expected to significantly affect groundwater concentrations at all of the monitoring wells. Seasonal variations can also cause groundwater concentrations to vary at one or more wells. As discussed above and in USEPA's (1993b, provided as Appendix A) draft *Supplemental Guidance to RAGS: Estimating Risk from Groundwater Contamination*, estimates of average COPC concentrations are recommended as EPCs for estimating chronic exposures in order to reduce uncertainties and inherent conservatism. As stated in USEPA (1993b; Appendix A), exposure estimates based on maximum detected concentrations across a group of monitoring wells or over time provide very low scientific confidence, as a single measurement cannot represent the COPC concentration present in the entire plume. USEPA (1993b; Appendix A) goes on to state, "It is appropriate for the assessor to target data from wells in the 'center' of the plume…. When targeting data from the more highly contaminated area of the plume, it is unlikely that the site-wide average will be underestimated." Therefore and as recommended by USEPA (1993b; Appendix A), groundwater EPCs will be based on the average of two-to-four quarters of monitoring data from NEB wells defining the "center" of the COPC plumes north of highway SR112.

The center of the NEB plume north of highway SR112 has been delineated at TEAD, and shown in Figure 3.3 (reproduced from Figure 4.5 of Parsons, 2004). Groundwater data collected from up to four of the most recent sampling events from the six monitoring wells (D-1 through D-5 and D-15) within the 5 µg/L TCE (the primary groundwater COPC at TEAD) contour line (D-1 through D-5 and D-15; refer to Figure 3.3) will be used to estimate 95-percent UCLs (calculated using methods described in Section 3.1.1) and used as groundwater EPCs. Data outside the 5 µg/L TCE contour line (i.e., century wells; Figure 3.3) will not be used in calculating EPCs since: 1) concentrations of TCE in these wells are below the MCL of 5 µg/L; and 2) using data

from the periphery of the plume would 'dilute' the groundwater EPC, resulting in lower estimates of risks and/or hazards.

3.2 METHODS FOR QUANTIFYING EXPOSURE

Estimating exposure involves quantifying the magnitude, frequency, and duration of exposure for the receptors and exposure pathways of concern. Following is a list of all potential exposure pathways that will be evaluated quantitatively at SWMU-58 (Section 2.2):

- Incidental ingestion of soil;
- Dermal contact with soil;
- Outdoor inhalation of volatiles from soil;
- Ingestion of groundwater; and
- Inhalation of COPCs volatilized from subsurface soil-gas into indoor air;

Specific methods that will be used to estimate exposure via each of these exposure pathways are described below.

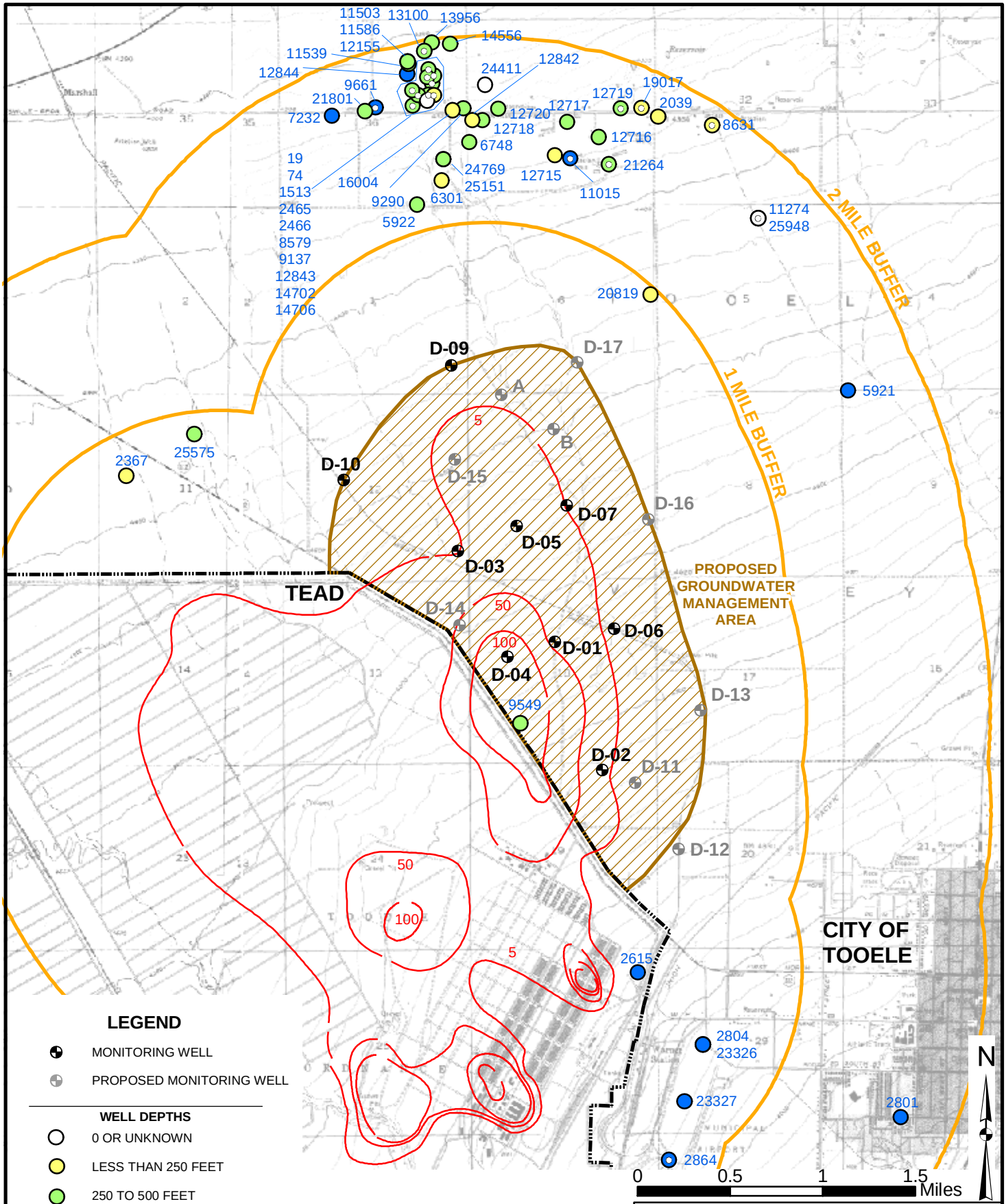
3.2.1 Incidental Ingestion of Soil

Per USEPA (1989a), potential exposure via incidental ingestion of soil will be estimated using the following equation.

$$\text{Intake} = \frac{(C_{soil})(IR_{soil})(EF)(ED)(FI)(CF)}{(BW)(AT)(365 days/year)}$$

where:

Intake = The amount of COPC at the exchange boundary (mg/Kg-day);
C_{soil} = COPC concentration in soil (i.e., EPC) (mg/Kg);
IR_{soil} = Soil ingestion rate (mg/day);
EF = Exposure frequency (days/year);
ED = Exposure duration (years);
FI = Fraction contaminated soil ingested (unitless);
CF = Conversion factor (10^{-6} Kg/mg);
BW = Body weight (Kg);
AT_c = Averaging time for carcinogens (years); and
AT_n = Averaging time for noncarcinogens (years).



Well ID number can have several water rights associated with it.
There are some water rights that have not been associated with a well.

FIGURE 3.3

PROPOSED GROUNDWATER MANAGEMENT AREA

TOOELE ARMY DEPOT

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Default and site-specific exposure parameters are discussed in Section 3.3. Exposure parameters were determined using USEPA (1989a, 1991a, 1992a, 1993a, 1996, and 1997a) recommended values, or site-specific information, where available.

3.2.2 Dermal Contact with Soil

Dermal exposure to contaminants in soil will be estimated using the methodology and algorithms described in *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim, Peer Review Draft* (USEPA, 2001b), *Dermal Exposure Assessment: Principles and Applications* (USEPA, 1992a), *Exposure Factors Handbook, Volume I, General Factors* (USEPA, 1997a), and from literature sources as cited. The dermally absorbed dose resulting from contact with contaminants in soil will be calculated per USEPA (1992a and 2001b) using the following algorithm.

$$DAD = \frac{(DA_{event})(EV)(ED)(EF)(ET)(SA)}{(BW)(AT)(365 days/year)}$$

where:

DAD = Dermally absorbed dose (mg/Kg-day);
DA_{event} = Absorbed dose per event per area of skin exposed (mg/cm^2-event);
EV = Event frequency (events/day);
ED = Exposure duration (years);
EF = Exposure frequency (days/year);
ET = Fraction of exposure frequency in contact with soil (unitless);
SA = Skin surface area available for contact (cm^2);
BW = Body weight (Kg); and
AT = Averaging time (years).

DA_{event} (milligrams per square centimeter [mg/cm^2]-event) for contaminants in soil will be calculated using the following equation (USEPA, 2001b and 1992a).

$$DA_{event} = (C_{soil})(AF)(DAF)(CF)$$

where:

DA_{event} = Absorbed dose per event per area of skin exposed (mg/cm^2-day);
C_{soil} = Contaminant concentration in soil (mg/Kg);
AF = Soil-to-skin adherence factor (mg/cm^2-day);
DAF = Dermal absorption fraction (unitless); and
CF = Conversion factor (10^{-6} Kg/mg).

Default and site-specific exposure parameter values are discussed in Section 3.3. Exposure parameters were determined using USEPA (1989a, 1991a, 1992a, 1993a, 1996, 1997a, 2001a, and 2001b) recommended values, or site-specific information, where available.

3.2.3 Outdoor Inhalation of Volatiles from Soil

Recent USEPA (1996) guidance does not recommend estimating intakes (i.e., milligrams per kilogram [mg/Kg]-day) for the air inhalation pathway. Rather, risks and hazards will be determined by comparing estimated volatile air concentrations, adjusted for exposure frequencies/durations/time, with inhalation toxicity values. Methods for estimating outdoor air concentrations of COPCs volatilized from soil are described in this subsection. Default and site-specific exposure parameter values are discussed in Section 3.3. Exposure parameters were determined using USEPA (1989a, 1991a, 1992a, 1993a, 1996, and 1997a) recommended values, or site-specific information, where available.

Per USEPA (1996), EPCs for COPCs volatilized from soils (assumed to present at the surface) into outdoor air will be based on the soil EPCs and estimated using the following equation.

$$C_{Air} = \frac{C_{Soil}}{VF}$$

where:

C_{Air} = COPC concentration in air at the exposure point (mg/m^3);
C_{Soil} = COPC EPC in soil (mg/Kg); and
VF = Chemical-specific volatilization factor (m^3/Kg).

The soil-to-air outdoor air volatilization factor (VF) is used to define the relationship between the concentrations of COPCs in soil and the flux of volatilized COPCs to outdoor air. USEPA (1996) provides default source concentration terms (called Q/C terms) based on meteorological conditions specific to 29 locations throughout the country and the size of the contaminant source. Per USEPA (1996), a Q/C value best representing the area's size and meteorological conditions at TEAD will be used in the VF calculation (specifically, the Q/C value for Salt Lake City, Utah). VFs will be

calculated using methods described in the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996) as follows:

$$VF = \frac{Q/C \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4}}{(2 \times \rho_b \times D_A)}$$

where:

VF	=	Volatilization factor (m^3/Kg);
Q/C	=	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per Kg/m^3);
D_A	=	Apparent Diffusivity (cm^2/s);
T	=	Exposure interval (s); and
ρ_b	=	Dry soil bulk density (g/cm^3).

D_A (cm^2/s) for COPCs in soil will be calculated using the following equation (USEPA, 1996):

$$D_A = \frac{[(\theta_a^{10/3} D_i H' + \theta_w^{10/3} D_w)/n^2]}{\rho_b K_d + \theta_w + \theta_a H'}$$

where:

θ_a	=	Air-filled soil porosity (L_{air}/L_{soil});
D_i	=	Diffusivity in air (cm^2/s);
H'	=	Henry's law constant (dimensionless);
θ_w	=	Water-filled soil porosity (L_{water}/L_{soil});
D_w	=	Diffusivity in water (cm^2/s);
n	=	Total soil porosity (L_{pore}/L_{soil});
ρ_b	=	Dry soil bulk density (g/cm^3); and
K_d	=	Soil-water partition coefficient (L/Kg).

In addition, soil saturation must be considered when calculating the VF (USEPA, 1996). Soil saturation corresponds to the COPC concentration in soil at which the adsorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the COPC in soil may be present in free-phase. Chemical-specific soil saturation concentrations must be compared with the concentration of each volatile soil COPC because a basic principle of the VF calculation is not applicable when free-phase contaminants are present. Therefore, the VF is applicable only if the soil COPC concentration is at or below the soil saturation concentration. Soil saturation concentrations (C_{sat}) will be calculated as follows (USEPA, 1996):

$$C_{sat} = \frac{S}{\rho_b} (K_d \rho_b + \theta_w + H'\theta_a)$$

where:

C_{sat} = Soil saturation concentration (mg/Kg);
S = Solubility in water (mg/L-water);
ρ_b = Dry soil bulk density (Kg/L);
K_d = Soil-water partition coefficient (L/Kg);
θ_w = Water-filled soil porosity (L_{water}/L_{soil});
H' = Henry's law constant (dimensionless); and
θ_a = Air-filled soil porosity (L_{air}/L_{soil}).

3.2.4 Ingestion of Groundwater

Per USEPA (1989a), potential exposure via ingestion of groundwater will be estimated using the following equation.

$$\text{Intake} = \frac{(C_{water})(IR_{water})(EF)(ED)(CF)}{(BW)(AT)(365 days/year)}$$

where:

Intake = The amount of COPC at the exchange boundary (mg/Kg-day);
C_{water} = COPC concentration in water (i.e., EPC) (µg/L);
IR_{water} = Water ingestion rate (L/day);
EF = Exposure frequency (days/year);
ED = Exposure duration (years);
CF = Conversion factor (mg/µg);
BW = Body weight (Kg); and
AT = Averaging time (years).

Default and site-specific exposure parameter values are discussed in Section 3.3. Exposure parameters were determined using USEPA (1989a, 1991a, 1992a, 1993a, 1996, 1997a, 2001a, and 2001b) recommended values, or site-specific information, where available.

3.2.5 Inhalation of COPCs Volatilized from Subsurface Soil-Gas into Indoor Air

Indoor air EPCs will be estimated using USEPA's (2003a) version of the Johnson and Ettinger model. This model (USEPA, 2003a) is a one-dimensional analytical solution to passive diffusion and convective vapor-transport through the vadose zone, and consists of the following two components: 1) diffusion through the unsaturated zone; and 2) convective and diffusive transport into the building.

3.2.5.1 Diffusion of Volatiles Through the Unsaturated Zone

Diffusion through the unsaturated (vadose) zone is estimated based on the following equation (USEPA, 2003a):

$$D_T^{eff} = D_a(\theta_a^{3.33} / n^2) + (D_W / H'_{TS})(\theta_w^{3.33} / n^2)$$

where:

D_T^{eff} = Total overall effective diffusion coefficient (cm^2/s);
D_a = Diffusivity in air (cm^2/s);
θ_a = Soil air-filled porosity (cm^3/cm^3);
n = Soil total porosity (cm^3/cm^3);
D_w = Diffusivity in water (cm^2/s);
θ_w = Soil water-filled porosity (cm^3/cm^3); and
H'_{ts} = Henry's law constant at the system temperature (dimensionless).

3.2.5.2 Convective and Diffusive Transport

Under the assumption that mass transfer is steady state, the solution for the attenuation coefficient (α) is calculated as (USEPA, 2003a):

$$\alpha = \frac{\left(\frac{D_T^{eff} A_B}{Q_{building} L_T}\right) \times e^{\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)}}{\left\{e^{\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)} + \left(\frac{D_T^{eff} A_B}{Q_{building} L_T}\right) + \left(\frac{D_T^{eff} A_B}{Q_{soil} L_T}\right) \times \left[e^{\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)} - 1\right]\right\}}$$

where:

α = Steady-state attenuation coefficient (unitless);
D_T^{eff} = Total overall effective diffusion coefficient (cm^2/s);
A_B = Area of the enclosed space below grade (cm^2);
$Q_{building}$ = Building ventilation rate (cm^3/s);
L_T = Source-building separation (cm);
Q_{soil} = Volumetric flow rate of soil gas into the enclosed space (cm^3/s);
L_{crack} = Enclosed space foundation or slab thickness (cm);
A_{crack} = Area of total cracks (cm^2); and
D_{crack} = Effective diffusion coefficient through the cracks (cm^2/s) (assumed equivalent to D_T^{eff}.

Indoor air concentrations ($C_{building}$) of chemicals volatilized from the subsurface soil are calculated using the following equation (USEPA, 2003a):

$$C_{building} = \alpha \times C_{source}$$

where:

α = Steady-state attenuation coefficient (unitless); and
C_{source} = Measured soil-gas concentration at the source (g/cm^3-v).

The electronic spreadsheets that are available for download from the USEPA website (www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm) incorporate the algorithms described above and will be used to estimate indoor air concentrations and subsequent risks and/or hazards associated with inhalation of chemicals volatilized from subsurface soil-gas into indoor air.

The effective total fluid saturation, soil intrinsic permeability, soil relative air permeability, and soil effective vapor permeability parameters are directly related to soil type (USEPA, 2003a). The subsurface geology at SWMU-58 is primarily sand and unconsolidated, poorly-sorted, coarse-grained alluvial fan deposits of varying thickness overlying a Paleozoic metasedimentary bedrock sequence. The most porous soil type ("sand") will be used in the model where site-specific parameters are unavailable. Input parameters, definitions, default values, and references used in the USEPA (2003a) volatilization model are shown in Table 3.2. Site-specific input values will be collected during the Phase II RFI effort for use in the model. Where site-specific data are unavailable, default values from Table 3.2 will be used.

3.3 EXPOSURE ASSUMPTIONS

The purpose of this section is to list default and site-specific exposure assumptions that will be used to estimate exposure to COPCs at SWMU-58. Primary exposure parameters that will be used to estimate exposure, brief statements on the justification for the parameter values selected, and references for these values are summarized in Tables 3.3 and 3.4. Most exposure parameters have a range of values. The exposure parameters listed in Tables 3.3 and 3.4 have been selected with the intent that the combination of variables for a given exposure pathway will result in an estimate of the reasonable maximum exposure (RME) for that pathway. The RME is defined as the highest exposure that reasonably could be expected to occur for a given exposure pathway at a site, and in practice is estimated by combining high-end (e.g., 90^{th} to 95^{th} percentile) values for some but not all exposure parameters (USEPA, 1989a, 1991a, 1992b, and 1993a). As discussed in *Guidance on Risk Characterization for Risk*

TABLE 3.2

INPUT PARAMETERS FOR MODELING VOLATILIZATION FROM SUBSURFACE MEDIA INTO INDOOR AIR
SWMU-58

TOOELE ARMY DEPOT - TOOELE VALLEY, UTAH

Parameter		Default Values	Reference	Proposed for Site-Specific Data Collection?
Symbol	Description			
C_g	Soil-gas concentration (ppmv)[a/]	Chemical and area-specific	NA[b/]	Yes
L_F	Depth below grade to bottom of enclosed space floor (cm)[a/]	15	USEPA, 2003a	Yes
Ls	Soil-gas sampling depth below grade (cm)	Sample-specific	NA	Yes
T_S	Average soil temperature (°C)[a/]	11	USEPA, 2003a	Yes
NA	SCS soil type	Sand[c/]	USEPA, 2003a	Yes
ρ_b	Soil dry bulk density (g/cm^3)[a/]	1.5	USEPA, 2003a (p. 19)	Yes
n	Soil total porosity (unitless)	0.43 (0.35-0.55; Conner, *et al.* , 1996)[d/]	USEPA, 2003a (p. 34)	Yes
θ_{ws}	Soil water-filled porosity (cm^3-water/cm^3-soil)[a/]	0.3 (0.13-0.52; Conner, *et al.* , 1996)	USEPA, 2003a (p. 29)	Yes
L_{crack}	Enclosed space floor thickness (cm)	10	USEPA, 2003a	Yes
ΔP	Soil-building pressure differential ($g/cm\text{-}s^2$)[a/]	40	USEPA, 2003a	Yes
L_B	Enclosed space floor length (cm)	1000	USEPA, 2003a	Yes
W_B	Enclosed space floor width (cm)	1000	USEPA, 2003a	Yes
H_B	Enclosed space height (cm)	366	USEPA, 2003a	Yes
W_B	Floor-wall seam crack width (cm)	0.1	USEPA, 2003a	Yes
ER	Indoor air exchange rate (1/hr)[a/]	0.83 (0.5-0.83; ASTM, 1995)	ASTM, 1995	Yes

[a/] Parameter units are defined as follows: ppmv = parts per million volume; cm = centimeter; °C = Degrees celcius; g/cm^3= Grams per cubic centimeter;

[b/] NA = Not applicable.
cm^3-water/cm^3-soil = Cubic centimeters of water per cubic centimeter of soil; $g/cm\text{-}s^2$ = Grams per centimeter per square second; 1/hr = inverse hour; L/min = Liters per minute.

[c/] Subsurface soil at SWMU-58 consists of sand and unconsolidated, poorly-sorted, coarse-grained alluvial fan deposits (Parsons, 2003a). The most porous soil-type, "sand", was used in the model.

[d/] Values in parenthesis indicate a typical range for these parameters; the reference is included for the range.

TABLE 3.3
SUMMARY OF EXPOSURE VARIABLES, SOIL AND SOIL-GAS PATHWAYS
TOOELE ARMY DEPOT-TOOELE VALLEY, UTAH

Exposure Variable	Receptor	Rationale	Reference
GENERAL (i.e., applies to all soil and soil-gas exposure pathways)			
EPC = Chemical concentration in soil (mg/Kg soil or ppbv soil-gas)	All receptors		
BW = Body weight 70 kg	All adult receptors	Average body weight for male and female adults	USEPA, 1991a and 2001a
EF = Exposure frequency 250 days/year 60 days/year	Indoor worker Intrusive worker	Assumes 5 days/week and absence of 10 days/year for vacation Assumes a 3-month intrusive project, 5 days/week	USEPA, 1991a Best judgment
ED = Exposure duration 25 years 1 year	Indoor worker Intrusive worker	Upper bound time for employment at a job Assume intrusive 3-month project occurs within a single year	USEPA, 1991a and 2001a Best judgment
AT = Averaging time 70 years (carcinogens) ED (noncarcinogens)	All receptors All receptors	Conventional human lifespan (exposure averaged over lifespan) Average over the exposure duration	USEPA, 1991a and 2001a USEPA, 1991a and 2001a
INCIDENTAL INGESTION OF SOIL			
IR = soil ingestion rate 330 mg/day	Intrusive worker	Default intrusive worker soil ingestion rate	USEPA, 2001a
FI = Fraction contaminated soil ingested 1 (unitless)	Intrusive worker	Conservatively assumes 100-percent of daily soil ingestion occurs on-site.	Conservative estimate
CF = Conversion factor 0.000001 kg/mg			Unit conversion factor
DERMAL CONTACT			
ET = Fraction of EF in contact with soil 1 (unitless)	Intrusive worker	Assumes soil contact/event occurs on-site	Conservative estimate
SA = Surface Area 3,300 cm^2	Intrusive worker	Assumes worker wearing short-sleeved shirt, long pants, and shoes; therefore, exposed body parts are the hands, forearms, and face. Body part-specific SAs summed.	USEPA, 2001a
AF = Soil adherence factor 0.3 mg/cm^2	Intrusive worker	Weighted based on activity and exposed body parts. See text for further details.	USEPA, 2001a

TABLE 3.3 (Continued)
SUMMARY OF EXPOSURE VARIABLES, SOIL AND SOIL-GAS PATHWAYS
TOOELE ARMY DEPOT-TOOELE VALLEY, UTAH

Exposure Variable	Receptor	Rationale	Reference
DAF = Dermal soil absorption factor (unitless)	Intrusive worker	Chemical-specific	USEPA, 2001b and literature as cited
OAF = Gastrointestinal oral absorption factor (unitless)	Intrusive worker	Chemical-specific	USEPA, 2001b; ORNL, 1998; or literature as cited
CF = Conversion factor 0.000001 Kg/mg			Unit conversion factor
INHALATION OF ORGANICS VOLATILIZED FROM SOIL ASSUMED PRESENT AT THE SURFACE			
ET = Fraction of EF breathing contaminated outdoor air 1 (unitless)	Intrusive and indoor workers	Assume at site 8 hrs/8 hr workday (i.e., 8 hr/8 hr = 1)	Best judgment
VF = Soil-to-air volatilization factor	Chemical-specific	Will be calculated per USEPA (1996) using site-specific Q/C term	USEPA, 1996
Q/C = Inverse of mean concentration at center of 0.5-acre-square source	All receptors	Per USEPA (1996), a Q/C value best representing the area's size and meteorological conditions at Tooele will be used in the VF calculation	USEPA, 1996
All other parameters used in the derivation of VF	All receptors	Default parameters listed in USEPA (1996) or site-specific	USEPA, 1996

TABLE 3.4
SUMMARY OF EXPOSURE VARIABLES, GROUNDWATER PATHWAYS
TOOELE ARMY DEPOT-TOOELE VALLEY, UTAH

Exposure Variable	Receptor	Rationale	Reference
GENERAL (i.e., applies to all groundwater exposure pathways)			
Cw = Chemical concentration in water (µg/L)	All receptors		
BW = Body weight 70 kg 15 kg	 Adult resident Child resident	 Average body weight for male and female adults Average body weight for male and female children	 USEPA, 1991a and 2001a USEPA, 1991b
EF = Exposure frequency 350 days/year	 Resident	 Assumes year-round residence and absence of 15 days/year for vacation	 USEPA, 1991a
ED = Exposure duration 30 years (24 adult; 6 child) 6 years	 Adult resident Child resident	 Assumes time-weighted residence of 30 years A child resident age 0-6.	 USEPA, 1991a USEPA, 1991a
AT = Averaging time 70 years (carcinogens) ED (noncarcinogens)	 All receptors All receptors	 Conventional human lifespan (exposure averaged over lifespan) Average over the exposure duration	 USEPA, 1991a and 2001a USEPA, 1991a and 2001a
INGESTION OF GROUNDWATER			
IR = Groundwater ingestion rate 2 L/day 1 L/day	 Adult resident Child resident	 USEPA default USEPA default	 USEPA, 1991a USEPA, 1991a
FI = Fraction contaminated water ingested 1 (unitless)	 All receptors	 Conservatively assumes 100-percent of daily water ingestion occurs from impacted plume.	 Conservative estimate
CF = Conversion factor 0.001 mg/µg			 Unit conversion factor

Managers and Risk Assessors (USEPA, 1992b), the most sensitive parameters should be identified and high-end values should be used for one or more of those variables. Studies of the compounding of conservatism in probabilistic risk assessments show that setting as few as two factors at RME levels or high end (e.g., near the 90th percentile), while the remaining variables are set at less conservative, typical or "central tendency" (CT) values results in a product of all input variables at an approximate RME level (e.g., 99th percentile value) (Cullen 1994). Central tendency/average values should be used for all other exposure parameters.

Generally, contact rate, exposure frequency, and exposure duration are the most sensitive parameters (i.e., likely to drive exposure estimates). When statistical data were available, 90th or 95th percentile values were selected for exposure duration. If distributions were not available (e.g., for intrusive workers), high-end estimates were made using best professional judgment. Typically, distributional data are not available for exposure frequency; therefore, high-end estimates have been made using available site-specific information and best professional judgment.

The following USEPA Office of Solid Waste and Emergency Response (OSWER) documents were considered when selecting default exposure parameters: *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Supplemental Guidance - Standard Default Exposure Factors. Interim Final* (USEPA, 1991a); *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Peer Review Draft* (USEPA, 2001a); *Risk Assessment Guidance for Superfund (RAGS) Volume I: Human health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. Peer Review Draft* (USEPA, 2001b); *Risk Assessment Guidance for Superfund, Volume I, Human Evaluation Manual (Part A), Interim Final* (USEPA, 1989a); and *Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure, Draft* (USEPA, 1993a). USEPA's 1991a guidance document received highest priority when selecting exposure parameters because: 1) it is an official OSWER publication (OSWER Directive 9285.6-03); 2) … "the factors presented … supersede those presented in Part A of USEPA (1989a) RAGS"; and 3) the 1993a USEPA publication was issued only as an internal review DRAFT document and was never finalized by USEPA OSWER (nor made publicly available).

Default values proposed in the two recently released USEPA (2001a and 2001b) peer review draft dermal and soil screening level (SSL) documents were used if: 1) values were not available in USEPA's 1991a document; or 2) the recommended values were based on more current data. Data presented in USEPA's (1997a) Exposure Factors Handbook were considered when values were not available from the USEPA OSWER documents listed above.

The hierarchical approach described above is consistent with the following statements from the 1993a USEPA OSWER Directive: "Accordingly, the exposure factors presented in this document are generally considered most appropriate and should be used in baseline risk assessments unless alternate or site-specific values can be clearly justified by supporting data. Supporting data for many of the parameters presented in this guidance can be found in the Exposure Factors Handbook. As new data become available, this guidance will be modified to reflect them." The justification for each parameter is discussed in the following subsections.

3.3.1 Body Weight

The USEPA (1991a, 2001b) recommended default body weight of 70 Kg will be used for all adult receptors. According to USEPA's (1997a) *Exposure Factors Handbook*, the average body weight for all adults (male and female) is 71.8 Kg (adapted from the National Center of Health Statistics). This value represents the average body weight for male and female adults between the age of 18 and 75 years. Per USEPA (1997a), the value of 71.8 Kg has been rounded to 70 Kg for use as the adult body weight to account for the estimated clothing weight (0.09-0.28 Kg) and to be consistent with the body weight used by USEPA (2004b) in the derivation of cancer slope factors and unit risks.

A value of 15 Kg will be used for the child body weight. This is the average body weight for children 1-6 years (USEPA, 1991b). The body weight value represents the average body weight over the exposure duration. Average body weight values will be used per USEPA (1991a and 1997a) recommendations, but also because body weight is correlated with other exposure parameters (e.g., intake and skin surface area).

3.3.2 Exposure Frequency

Exposure frequency is site-specific based on expected activities for each of the receptors. Therefore, national data on the distribution of exposure frequencies are not

available. Consistent with the RME approach described above, high-end estimates of exposure frequencies will be used for each of the receptors evaluated in the HRA and are discussed below.

The USEPA (1991a) value of 350 days/year for residents will be used as the high-end exposure frequency estimate. This assumes a year-round resident and an absence of 15 days/year for vacation. The USEPA (1991a and 2001a) recommended high-end exposure frequency estimate of 250 days/year will be used for the indoor worker that works at an existing/future building located at SWMU-58. A high-end estimate of 60 days/year will be used for the intrusive worker. The intrusive worker may be involved in short-term activities such as construction of temporary or permanent structures or installation/repair of utility lines (e.g., buried cables, pipes). The value of 60 days/year is a high-end estimate and is based on the assumption that intrusive activities may last up to three months in duration and that the receptor would work at the site 5 days/week (i.e., 60 days total).

3.3.3 Exposure Duration

As recommended by USEPA (1991a), an exposure duration of 30 years will be used for a resident; 24 years as an adult and six years as a child. Age-dependent exposure assumptions, including exposure durations will be time-weighted, as discussed in USEPA (1989a and 1991b).

An exposure duration of 25 years will be used for the indoor worker, as this is the upper-bound time employment at a job (USEPA, 1991a). An exposure duration of one year will be used for the intrusive worker. This value is based on the assumption that a 3-month construction project will be completed within a single year. While it is possible that 3-month construction projects may occur over a period of one year, it is not likely that the exposure frequency for the intrusive worker would change (i.e., workers would be exposed the same number of days/year).

3.3.4 Averaging Time

The averaging time selected depends on the type of toxic effect being assessed (USEPA, 1989a). Exposure is averaged over an individual's lifetime for carcinogens and the period of exposure (i.e., the exposure duration) for noncarcinogens. Although current data suggest that 75 years would be an appropriate value to reflect the average life

expectancy of the general population (USEPA, 1997a), the USEPA (1991a, 2001a) recommended averaging time of 70 years will be used to be consistent with the derivation of USEPA (2004b) cancer slope factors and unit risks. For noncarcinogens, the averaging time will be equal to the exposure duration for each of the receptors evaluated.

3.3.5 Skin Surface Areas

The skin surface area (SA) parameter describes the amount of skin exposed to the contaminated media. The amount of skin exposed depends upon the exposure scenario. Clothing is expected to limit the extent of the exposed SA in cases of soil contact.

The USEPA (2001a and 2001b) recommended SA of 3,300 cm^2 will be used for the intrusive worker (the only receptor exposed to soil COPCs via dermal contact; Section 2.2). Per USEPA (2001b), this value is based on the assumption that workers will wear short-sleeved shirts, long pants, and shoes, therefore, the exposed body parts will be the hands, forearms, and face. This is a 50^{th} percentile value to correlate with the average body weight used for an intrusive worker.

3.3.6 Contact Rates

Contact rates reflect the amount of contaminated medium contacted per unit time or event. As discussed previously, exposure parameters have been selected with the intent that the combination of variables for a given exposure pathway will result in an estimate of the RME. To avoid estimates that likely will be outside the distribution of actual exposure, average contact rates will be paired with high-end exposure frequencies and durations.

3.3.6.1 Soil Ingestion Rates

Incidental soil ingestion rates depend on the receptor being evaluated. Incidental ingestion of soil will only be evaluated for intrusive workers (Section 2.2). The USEPA (2001a) recommended default value of 330 mg/day will be used for intrusive workers. Per USEPA (2001a), this value is based on the 95th percentile value for adult soil intake rates reported in a soil ingestion mass-balance study by Stanek *et al.* (1997).

3.3.6.2 Groundwater Ingestion Rates

Water ingestion rates depend on the receptor being evaluated. Ingestion of groundwater will be evaluated for residents (Section 2.2). The USEPA (1991a)

recommended default value of 2 L/day will be used for adult residents, and 1 L/day for child residents (USEPA, 1991a).

3.3.6.3 Soil Adherence Factors

The adherence factor (AF) describes the amount of soil that adheres to the skin per unit of surface area. Recent data from Kissel's laboratory (Kissel *et al.*, 1996a; Kissel *et al.*, 1996b; Kissel *et al.*,1998; and Holmes *et al.*, 1999) provide evidence to demonstrate that:

- Soil properties influence adherence;
- Soil adherence varies considerably across different parts of the body; and
- Soil adherence varies with activity.

Given these results, USEPA (1997a) recommends that activities which best represent all soils, body parts, and activities be used to derive soil adherence factors (AFs). The body part-weighted AF of 0.3 mg/cm^2 for an intrusive worker recommended by USEPA (2001a) will be used. Refer to USEPA (2001b) RAGS, Part E for more information regarding the calculation of body part-weighted soil AFs.

3.3.6.4 Inhalation Rates

The inhalation chronic toxicity factors derived by USEPA (2004b) (i.e., inhalation unit risks (IURs) and reference concentrations (RfCs) are expressed as air concentrations. USEPA (1994, 1996) recommends direct comparison of measured or modeled air concentrations to inhalation toxicity factors rather than using daily inhalation rates to convert to internal doses (i.e., mg/Kg-day). Therefore, direct comparison of measured or modeled air concentrations to inhalation toxicity factors without converting to internal doses is appropriate.

3.3.7 Fraction Contaminated

The fraction contaminated exposure parameter (e.g., fraction ingested) is defined as the fraction of medium (e.g., soil) contacted that is presumed to be contaminated. Fraction contaminated is dependent on the medium and exposure pathway being evaluated.

A value of one for the fraction contaminated will be used for the ingestion and dermal exposure pathways. This approach conservatively assumes that 100-percent of a

receptor's daily exposure to the specified medium via ingestion and dermal contact occurs on-site.

3.3.8 Other Exposure Parameters

Additional pathway- and chemical-specific exposure parameters listed in Tables 3.2 through 3.4 are discussed in this subsection.

3.3.8.1 Chemical-Specific Exposure Parameters

Chemical-specific parameters that will be used in the HRA will be based on appropriate site-specific data, USEPA recommendations, values reported in the scientific literature, or best scientific judgment. A reference for each value (e.g., dermal soil absorption factors, soil-to-air volatilization factors, skin permeability coefficients) will be included in a table listing chemical-specific properties used in the HRA.

3.3.8.2 Fraction of Time Breathing Contaminated Air

Chronic inhalation toxicity factors developed by USEPA (2004b) assume continuous (i.e., daily, 24-hour exposure) long-term exposure. Therefore, it is necessary to adjust for the fraction of time breathing contaminated air for exposures less than 24 hours. Per USEPA (2001a), inhalation rates increase with activity, and select worker inhalation rates for an 8-hour day may approach inhalation rates for a 24-hour day (residential receptor). Therefore, a default value of 1.0 (unitless) will be used for the fraction of time intrusive and indoor workers will spend breathing contaminated air, assuming they work at the site up to 8 hours/day (i.e., 8 hours/8-hour workday = 1.0).

3.3.8.3 Parameters Used for Modeling Volatilization from Subsurface VOCs into Indoor Air

Input parameters, definitions, default values, and references used in the USEPA (2003a) volatilization model are shown in Table 3.2 Site-specific input values will be collected during the Phase II RFI effort for use in the model. Where site-specific data are unavailable, default values from Table 3.2 will be used.

SECTION 4.0
TOXICITY ASSESSMENT

In order to evaluate the risks/hazards associated with potential exposure to COPCs at a site, the types of health effects that may result from exposure to each COPC and the quantitative relationship between the amount of exposure and the extent of potential effects must be identified. Per USEPA (1989a), the toxicity assessment step includes the identification of appropriate exposure periods (e.g., chronic) and the determination of carcinogenic/noncarcinogenic toxicity factor (refer to Figure 4.1). The objectives of the toxicity assessment are to weigh available toxicological evidence regarding the potential for particular chemicals to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a chemical and the increased likelihood and/or severity of adverse effects (i.e., toxicity factors).

The methodologies used to develop toxicity factors differ, depending on whether the COPC is a potential carcinogen (produces tumors) or a non-carcinogen (produces adverse health effects such as liver toxicity, kidney toxicity, neurotoxicity, etc.). The most recently available toxicity factors will be used to calculate carcinogenic and noncarcinogenic risks/hazards based on the following general hierarchy of sources recommended by USEPA (2003b) for toxicity factors:

- USEPA's (2004b) Integrated Risk Information System (IRIS);
- USEPA's (http://hhpprtv.ornl.gov/) Provisional Peer-Reviewed Toxicity Values (PPRTVs)
- Other (peer-reviewed) Values, including
  - ATSDR's Minimal Risk Levels
  - California Environmental Protection Agency (CalEPA) values
  - National Center for Environmental Assessment (NCEA) values
  - HEAST (USEPA, 1997c)

Oral toxicity values reflect administered-dose values, which represent concentrations that will be protective following ingestion. Inhalation toxicity values are

representative air concentrations that will be protective following inhalation (24 hours/day). The dermal route of exposure, however, evaluates the toxicity of concentrations of chemicals in the blood (absorbed dose). Therefore, the absorbed-dose concentrations identified for dermal exposure must be compared to toxicity values adjusted for gastrointestinal absorption (USEPA, 2001b). Toxicity values adjusted for gastrointestinal absorption are derived by applying oral absorption factors to administered-dose toxicity values. Adjustment of an oral slope factor (CSFo) or reference dose (RfD) will be performed when the following conditions are met (USEPA, 2001b):

- The critical study upon which the toxicity value is based employed an administered dose (e.g., delivery in diet or by gavage) in its study design;
- A scientifically defensible data base exists and demonstrates that the gastrointestinal absorption of the chemical in question, from a media (e.g., water, feed) similar to the one employed in the critical study, is less than 100-percent; and
- Oral absorption factors will be obtained from the literature (citations will be provided; e.g., values used by USEPA (2001b) and/or USEPA Region 9 [2002]).

A summary of all toxicity factors used in the HRA calculations will be provided in the results section of the risk assessment.

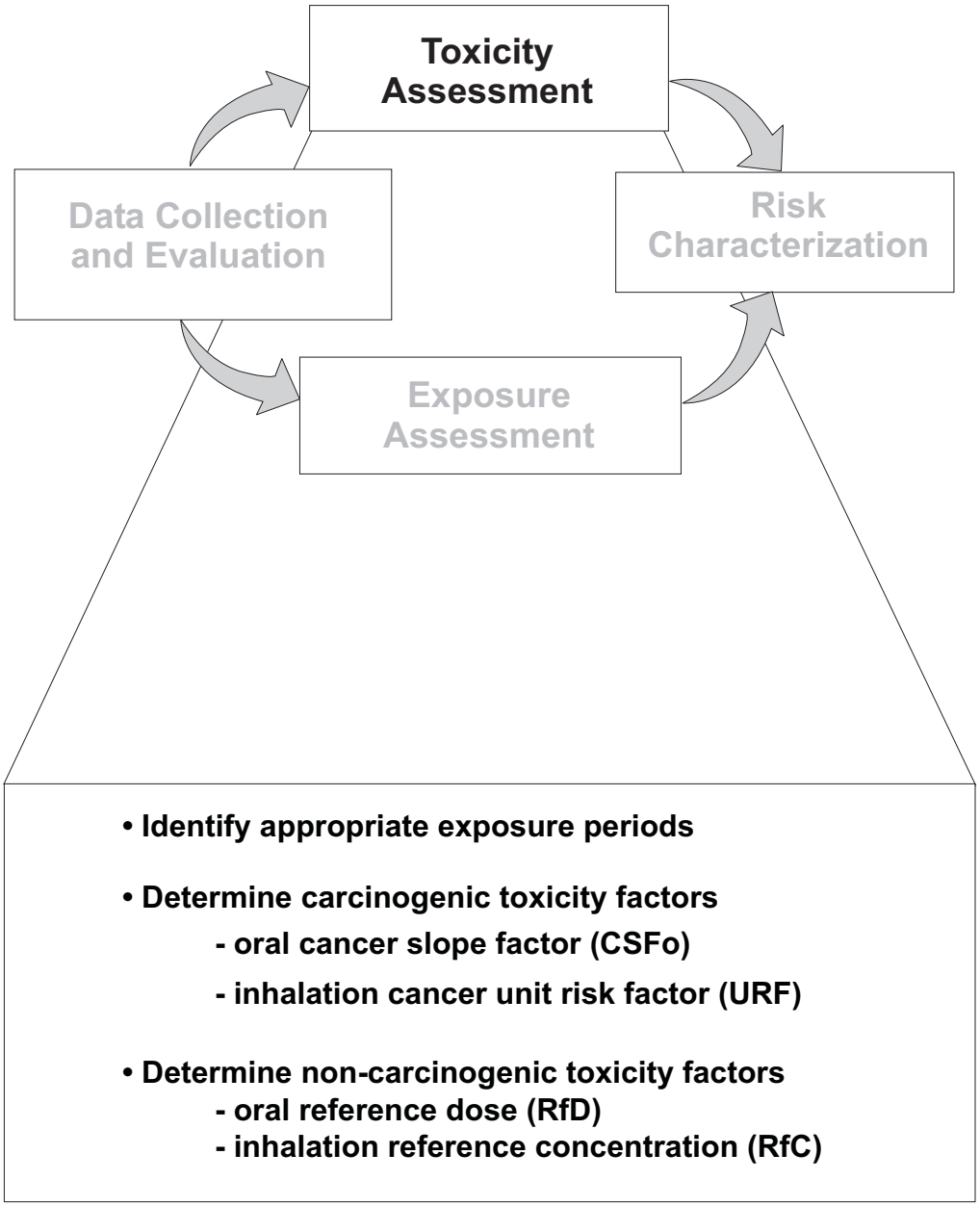

FIGURE 4.1

TOXICITY ASSESSMENT

Tooele Army Depot-Tooele Valley, Utah

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SECTION 5.0
RISK CHARACTERIZATION AND UNCERTAINTIES

The purpose of the risk characterization step is to 1) review the results from the exposure and toxicity assessments; 2) quantitatively estimate the potential for cancer (i.e., risk) and non-cancer (i.e., hazard) effects; and 3) assess and discuss uncertainties associated with all the risk assessment steps (refer to Figure 5.1). To characterize potential non-carcinogenic effects, comparisons will be made between estimated exposure levels of COPCs and their toxicity values. To characterize potential carcinogenic effects, the incremental probability of an individual developing cancer over a lifetime will be calculated from estimated exposure levels and chemical-specific dose/response information (i.e., carcinogenic toxicity factors). Cancer risk (for carcinogens) and HQ (for non-carcinogens) estimates will be calculated as described below for each COPC having available toxicity factors.

5.1 NON-CARCINOGENIC EFFECTS

The potential for non-carcinogenic effects will be evaluated by comparing the estimated exposure level over a specified time period with non-carcinogenic toxicity factors derived for a similar exposure period. This ratio is termed the HQ, or in other words, the HQ is the ratio of the exposure level to the non-cancer toxicity factor:

Oral HQ = exposure intake (administered dose)/oral RfD (administered dose);

Inhalation HQ = modeled air concentration X exposure factors/RfC, as shown in the following equation:

$$\frac{(C_{(air\ -\ VOC)})(EF)(ED)(ET)}{(AT)(365 days/year)} \ / \ \text{RfC},$$

where:

$C_{(air--VOC)}$ = For soil: Csoil /VF , where

Csoil = COPC concentration in soil (i.e., EPC); and

VF = Volatilization factor (m^3/Kg);

EF = Exposure frequency (days/year);

ED = Exposure duration (years);

ET = Fraction of EF time breathing air at the site;
AT = Noncancer averaging time (years); and
Dermal HQ = intake (absorbed dose)/oral RfD (absorbed dose).

The HQ approach assumes that there is a level of exposure (i.e., RfD or RfC) below which it is unlikely that even sensitive populations would experience adverse health effects. If the exposure level exceeds the threshold (i.e., if HQ exceeds unity), there may be concern for potential noncancer effects. Per USEPA (1989a), the greater the HQ above unity, the greater the level of potential concern.

5.2 CARCINOGENIC EFFECTS

Carcinogenic risk is expressed as an increased probability of developing cancer as a result of lifetime exposure. For a given COPC and route of exposure, carcinogenic risk will be calculated as follows:

Oral risk = exposure intake (administered dose) x oral slope factor (administered dose);
Inhalation risk = modeled air concentration x exposure parameters IUR, as shown in the following equation:

$$\frac{(C_{(air\text{-}VOC)})(EF)(ED)(ET)}{(AT)(365 days/year)} * \text{IUR}$$

where:
$C_{(air\text{--}VOC)}$ = For soil: Csoil /VF , where
Csoil = COPC concentration in soil (i.e., EPC) (mg/Kg);
VF = Volatilization factor (m3/Kg);
EF = Exposure frequency (days/year);
ED = Exposure duration (years);
ET = Fraction of EF time breathing air at the site (unitless);
AT = Noncancer averaging time (years); and
Dermal risk = intake (absorbed dose) x oral SF (absorbed dose).

5.3 CUMULATIVE EFFECTS

To assess the overall potential for noncarcinogenic effects posed by more than one exposure route and more than one chemical (i.e., cumulative hazards from exposure to multiple COPCs via multiple exposure routes), a hazard index (HI) approach has been

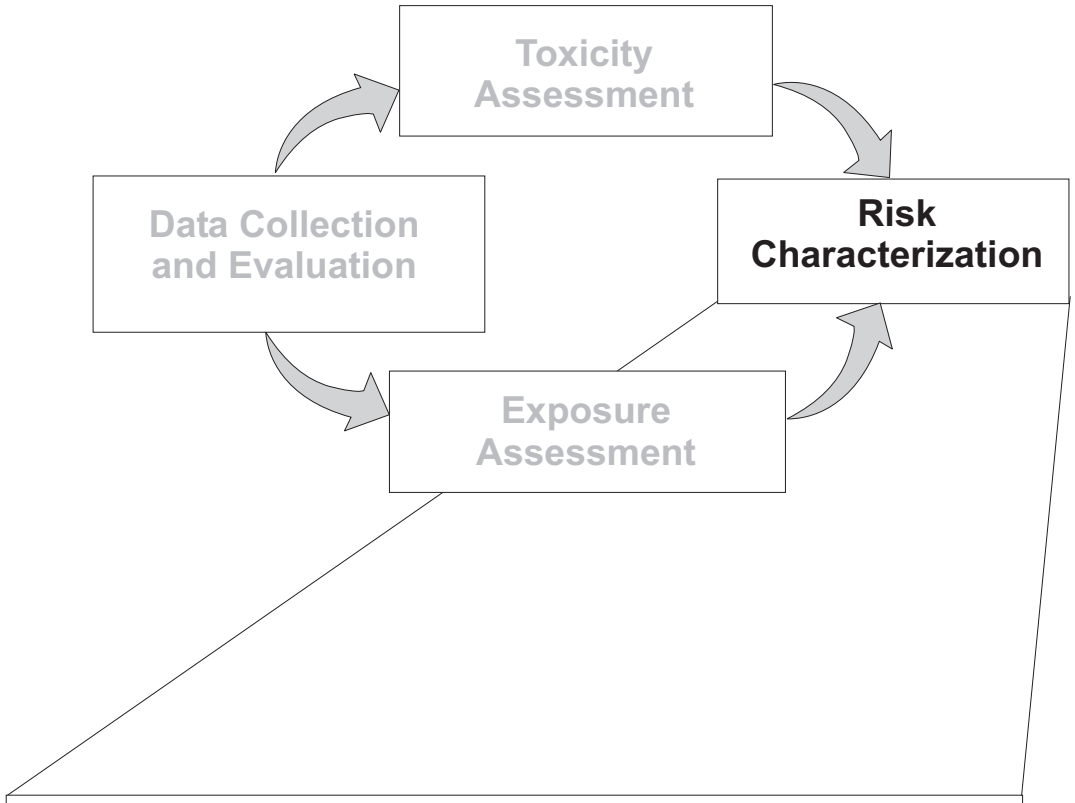

FIGURE 5.1

RISK CHARACTERIZATION

Tooele Army Depot-Tooele Valley, Utah

PARSONS

developed by the USEPA (1989a). This approach assumes that simultaneous subthreshold exposures to several chemicals via multiple exposure routes could result in an adverse health effect, while acting on the same target organ. The HI is calculated as follows:

$$HI = HQ_1 + HQ_2 + ... + HQ\mathit{i}$$

where:

HQ*i* = the hazard quotient for the *i*th toxicant summed across all relevant exposure routes.

According to USEPA (1989a) guidance for estimating risk from exposures to noncarcinogens, HI values can be derived based on similar target organ effects (if necessary). For those receptors with HIs exceeding one, cumulative HIs by target organ may be calculated per USEPA (1989a) guidance.

Calculation of an HI in excess of one indicates the potential for adverse health effects. Indices greater than one will be generated any time estimated exposure for any of the COPCs exceeds its RfD or RfC. If there are two or more COPCs, it is possible to generate a HI greater than one, even if none of the estimated exposure levels for individual COPCs exceed their respective RfDs or RfCs.

For simultaneous exposure to several carcinogens via multiple exposure routes, cumulative risk will be calculated using the following equation:

$$Risk_T = Risk_1 + Risk_2 + ... + Risk_i$$

where:

$Risk_T$ = the total cancer risk, expressed as a unitless probability; and

$Risk_i$ = the risk estimate for the *i*th substance summed across all relevant exposure routes.

Per UAC R315-101 (DSHW, 2001), no further action (NFA) target risk and hazard levels for the residential land-use scenario will be 1×10^{-6} for carcinogens and a HI greater than one for noncarcinogens. For actual/potential land use conditions based upon applicable zoning and future land use planning considerations (i.e., industrial land

use), corrective action will not be required if the estimated HI and cancer risk for the industrial receptors are less than one and 1 x 10^{-4}, respectively (DSHW, 2001).

5.4 UNCERTAINTIES

All risk assessments involve the use of assumptions, professional judgments, and imperfect data to varying degrees, which results in uncertainty in the final estimates of hazard and risk. Risk assessment in general is highly conservative and often is based on conservative assumptions and scenarios. Uncertainty can be introduced into a health risk assessment at every step of the process outlined in this document. Uncertainties are present in a risk assessment because it requires the integration of the following:

- The release of pollutants into the environment;
- The fate and transport of pollutants, in a variety of different and variable environments, by processes that are often poorly understood or too complex to quantify accurately;
- The potential for adverse health effects in humans based on extrapolations from animal studies; and
- The probability of adverse effects in a human population that is highly variable with respect to genetics, age, activity level, and lifestyle.

There are several categories of uncertainty associated with risk assessment. One is the initial selection of chemicals for analyses and, therefore, which chemicals are used to characterize risk from exposure. A second category is the selection of exposure scenarios that are conservative (i.e., protective of human health) and yet which are probable. Additional uncertainties are inherent in the exposure assessment for individual substances and individual exposures. Those uncertainties are driven by the degree of reliability of the chemical monitoring data, the models used to estimate EPCs in the absence of monitoring data, and the population intake parameters (e.g., exposure factors). A third category is the availability of toxicity information for the COPCs at the site to address all potential routes of exposure. Finally, additional uncertainties are incorporated into the risk assessment when exposures to several substances are summed. The likelihood that approaches incorporated into the methodologies may result in overestimating or underestimating actual risks/hazards associated with exposure to site COPCs will be described (qualitatively and/or quantitatively) in the HRA.

SECTION 6.0

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APPENDIX A

USEPA's (1993b) DRAFT SUPPLEMENTAL GUIDANCE TO RAGS: ESTIMATING RISK FROM GROUNDWATER CONTAMINATION

Environmental Protection Agency
Emergency Response
Washington, D.C. 20460
December 1993

Supplemental Guidance to RAGS: Estimating Risk from Groundwater Contamination

Office of Emergency and Remedial Response
Hazardous Site Evaluation Division

Intermittent Bulletin
Volume X Number X

The Toxics Integration Branch and Regional risk assessors have formed a Total Quality Management (TQM) Quality Action Team (QAT), known as the Concentration Term workgroup, to address the broad goal of improving the quality of data used in baseline risk assessments.

For this fact sheet, the Concentration Term workgroup consulted with representatives of the Groundwater Forum to address the risk assessment challenges posed by groundwater, in particular.

Calculating Risk

Risk at Superfund sites generally is calculated by comparing estimates of human exposure with Agency-verified toxicity criteria. Exposure is calculated by combining concentration with other parameters, such as the contact rate, exposure frequency and duration, and body weight. Current Agency guidance (U.S. EPA, *Guidance on Risk Characterization for Risk Managers and Risk Assessors*, February 26, 1993) requires risk assessments to present multiple descriptors of risk, including estimates for both average and high-end exposure scenarios. The Superfund site manager uses the calculated risk value to help determine the need for and extent of contaminant cleanup. Since risk and exposure are linearly related, the pollutant's concentration has a significant influence on the risk analysis, and, consequently, the remedial decision at a given site. The calculation of the concentration term is crucial; miscalculation could result in a false estimate of risk and, ultimately, result in inappropriate cleanup decisions and misdirected Superfund actions.

The Superfund program uses a reasonable maximum exposure (RME) or high-end risk calculation as the basis for remedial decisions. RME is intended to estimate a conservative case that is both protective of human health and the environment, while remaining within the range of potential exposure levels.

Because groundwater is a very complex and dynamic medium with characteristics that can change seasonally, it is likely that concentration of a given contaminant in each well will vary over time. Therefore, the concentration term is best described by an arithmetic average, regardless of whether the overall exposure estimate is high-end or average. Time and resource considerations generally preclude collecting enough data to calculate a true average; therefore, Superfund has relied on an upper-confidence limit on the arithmetic mean (UCL_{95}) to represent the average concentration.

The Challenge of Groundwater Risk Assessment

When determining the need for action, there are both policy and technical issues that set groundwater apart from other media, such as soil. EPA's policy is to consider the maximum beneficial use of groundwater and to protect it against future contamination. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (U.S. EPA Publication 9200.2-14, January 1992) states that groundwater is an inherently valuable natural resource to be protected and restored where necessary and practical, as groundwater that is not currently used may be a drinking water supply in the future. An example of this practice is where a deeper, uncontaminated aquifer is hydraulically connected to a shallow, contaminated aquifer.

(continued on p.2)

(continued from p.1)

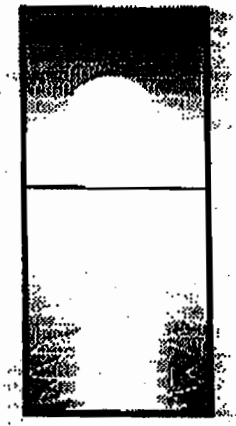
Although the shallow aquifer may not currently be a drinking water resource, EPA may choose to remediate it to protect the deeper aquifer. In addition, few states have designated aquifers as unpotable, resulting in most aquifers being considered drinking water sources that must be addressed in the risk assessment.

These policies are sometimes at odds with Superfund's attempts to reasonably assess potential risks to human health. Risk assessment should be based upon the likelihood that a person will be continuously exposed to the contaminants present at the site over time. In a true assessment of risk, the usability of the aquifer must be considered. This includes such factors as the quality of the water (pH, redox potential, salinity, etc.), the size of the aquifer, the hydraulic characteristics, the community's water needs, and the availability of other drinking water sources.

Technical issues center around the characteristics of groundwater and make estimating long-term exposures particulary difficult. Most groundwater plumes move over time. The rate at which the plume moves, both horizontally and vertically, can greatly affect the concentration of contaminants at the same well. Seasonal variations in precipitation can cause low-to-high shifts in the groundwater table, flushing some contaminants out of the sample area.

The complexity of groundwater as a medium has a very definite impact on the ability to calculate a reliable concentration term. Because the concentration term is key to determining risk, it is imperative that the risk assessor has enough information to properly calculate the concentration term. Analysis has shown that as the number of samples increases, the degree of uncertainty and inherent conservatism is reduced. Preliminary results with soil analyses have shown that data from 10 to 20 samples per exposure area can support the calculation of a UCL_{95} that is reasonably close to the true mean.

Risk assessors have found that groundwater pollutant concentration data collected during the remedial investigation often are insufficient to support a statistically meaningful average. For groundwater, the exposure area is difficult to define, and due to the expense and labor required to install monitoring wells, adequate data may not be available for risk analysis use. If the available data cannot support statistical calculation of a pollutant's average concentration, the risk assessor is forced to calculate risk values from a single concentration measurement, usually relying on a maximum value. This approach provides very low scientific confidence, as a single measurement cannot represent the contamination present in the entire plume. Thus, the risk assessors and site managers must reach a compromise between the desire for the optimum amount of data and the cost of installing and sampling wells.



For More Information

Additional information on Superfund's policy and approach to calculating risk at groundwater sites can be obtained in:

- U.S. EPA, *Risk Assessment Guidance for Superfund (RAGS): Volume I—Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, December 1989.
- U.S. EPA, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, Publication 9285.7-081, March 1992.
- U.S. EPA, *Guidance for Data Usability in Risk Assessment*, EPA/540/G-90/008 (OSWER Directive 9285.7-09), October 1990.
- U.S. EPA, *Guidance on Risk Characterization for Risk Managers and Risk Assessors*, memorandum from F. Henry Habicht II to Assistant and Regional Administrators, February 26, 1993. (Available from the Office of the Administrator.)
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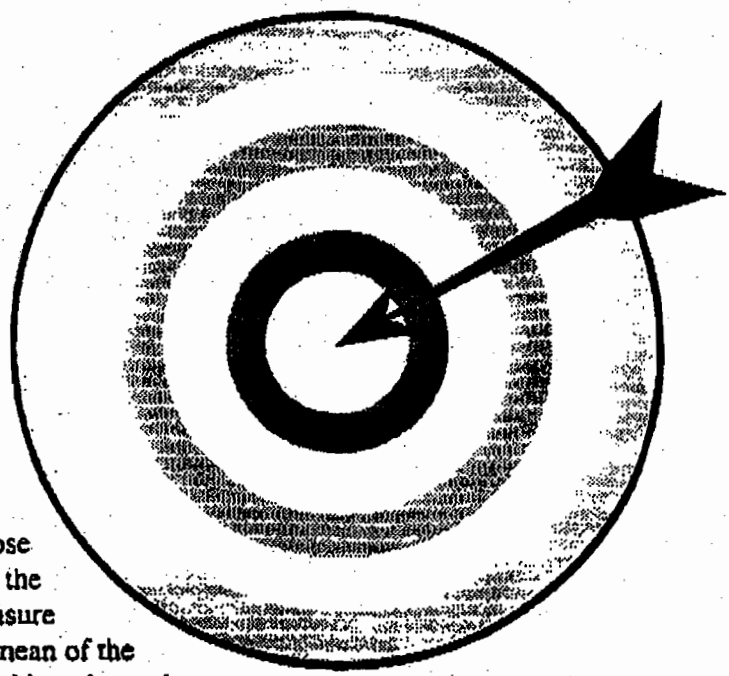
Targeting Groundwater Risk



Members of the Groundwater Forum provided the following description of a groundwater site investigation. First, they stated that it is common practice in the initial phases of a groundwater site investigation to install between five to six wells across the site, targeting source areas and potential downgradient migration. Second, around wells with high hits, one or two additional wells may be installed to further define the "center of the plume." Finally, once the "center" has been located, future efforts focus on defining the extent of contamination downgradient of the "center." The number of sampling rounds varies from site to site, but four quarters' worth of data will provide a very good picture of the influence of seasonal changes on the level of the water table.

Although other exposure estimates are made, the NCP directs that the risk assessment focus on estimating an RME. Therefore, it is appropriate for the assessor to target data from wells in the "center" of the plume. As stated above, the assessor may have data from only two or three wells, and calculation of a meaningful UCL_{95} requires 10 to 20 samples. The primary purpose of calculating the UCL_{95} is to ensure that the true mean of the entire site would not be underestimated, as is common with limited data sets. However, in this case, we are targeting data from the more highly contaminated area of the plume, and it is unlikely that the site-wide average will be underestimated. Thus, for the concentration term in groundwater risk assessments, it is sufficient to take the simple arithmetic average of sample data obtained from two to three wells in the "center" of the plume. Again, to account for the impact of seasonal variations, data from at least two quarters is required, and data from four quarters is preferred.

This guidance is most applicable to sites where groundwater is not currently used for drinking water. For residential wells that are currently in use, action may be taken where "Removal Action Levels" are exceeded. This action can be taken based on one round of sampling with confirmation analyses.

State of Utah

Department of Environmental Quality

Dianne R. Nielson, Ph.D.
Executive Director

DIVISION OF SOLID AND HAZARDOUS WASTE
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October 26, 2005

Tom Turner, Chief
Industrial Risk Management
Tooele Army Depot
Tooele, Utah 84074-5000

Re: Response to Comments, Supplemental Risk Assessment from Exposure to Volatile Organic Compounds in Shallow Subsurface Soils, SWMU 58, Draft Final, Tooele Army Depot, Utah (EPA #UT3213820894)

Dear Mr. Turner:

We have completed our review of the response to comments, dated October 10, 2005. All of the responses are deemed adequate, with the following exceptions:

1) Original Comment #2: The text states that an average TOC value of 4700 mg/kg, rather than 4800 mg/kg would result, if the average were calculated by substituting zero instead of one-half the method detection limit (MDL) for non-detects, which is an insignificant difference. As we were unable to follow the narrative in the text, please back up that statement with a supporting step-by-step calculation.

2) Original Comment #4: The text states that the actual HI for an intrusive worker at Area 2 would still be less than one, even with incorporating depth into the spatially weighted estimate (since the assessment is based on potential exposure to an intrusive worker). Again, as we were unable to follow the narrative in the text, please back up that statement with supporting step-by-step calculation.

3) Original Comment #5: At a minimum, more information is required. If the "new" USEPA TCE toxicity values are used, corrective action is required at SWMU 58. The protective action would be for TEAD to do corrective action. If TEAD chooses not to do corrective action, the response to comment should provide a rationale why the DSHW shouldn't require corrective action, i.e., why would site management be adequately protective? While a discussion of the uncertainties with the toxicity of TCE is germane, it cannot be the only reason because EPA HQ recommends the use of the new toxicity values. The Utah rules require that decisions be made on USEPA toxicity values, and not on Army values. (TCE toxicity is not the only chemical with which the Army disagrees.

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The Army also disagrees with USEPA toxicity values for perchlorate and RDX.) If the rationale presented is insufficient, or if the USEPA adopts the more conservative TCE values into IRIS, corrective action will be required.

Please address these remaining issues by December 2, 2005. Thank you for your continuing and professional cooperation. If you have any questions, please contact Helge Gabert or Chris Bittner of my staff at 538-6170.

Sincerely,

Dennis R. Downs, Executive Secretary
Utah Solid and Hazardous Waste Control Board

DRD\HG\ts

c: Myron Bateman, M.P.H., R.S., Health Officer/Director, Tooele Co. Health Dept.
Jim Kiefer, USEPA Region VIII
Larry McFarland, TEAD
Maryellen Mackenzie, U.S. Army Corps of Engineers, Sacramento
Carl Cole, U.S. Army Corps of Engineers, TEAD

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